AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

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SENEGAL

AGRICULTURAL SECTOR RISK ASSESSMENT

Stephen D'Alessandro, Amadou Abdoulaye Fall, George Grey,
Simon Simpkin, and Abdrahmane Wane

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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
ARMT	Agricultural Risk Management Team
CAADP	Comprehensive Africa Agriculture Development Programme
CBPP	Contagious Bovine Pleuropneumonia
CA	Conservation Agriculture
CFA	CFA franc
CSE	Centre de Suivi Ecologique
CNASS	Compagnie Nationale d'Assurances Agricole du Sénégal
DAPS	Direction de l'Analyse de la Prévision et des Statistiques
DNCB	Dermatose Nodulaire Contagieuse Bovine
DPC	Directorate of civil protection
DRR	Disaster risk reduction
FAO	Food and Agriculture Organization of the UN
FAOSTAT	FAO Statistics
FMD	Foot and Mouth Disease
GCM	General Circulation Model
GDP	Gross Domestic Product
G-8	Group of Eight
GOS	Government of Senegal

Acronym	Definition
Ha	Hectare
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
ISRA	Institute Sénégalais de Recherches Agricoles
LSD	Lumpy Skin Disease
LGP	Length of Growing Period
MEF	Ministry of Economy and Finance
MT	Metric tons
NAPA	National adaptation programme of action
NCD	Newcastle Disease
NDVI	Normalized Difference Vegetation Index
OIE	Organisation International des Epizooties.
PPCB	Pleuropneumonie Contagieuse Bovine
PPP	Public-private Partnership
PPR	Peste de Petits Ruminants
SODEFITEX	Société de Développement et des Fibres Textiles
TLU	Tropical Livestock Units
USAID	U.S. Agency for International Development
WFP	World Food Programme
XAF	CFA franc

ACKNOWLEDGMENTS

To better understand dynamics of agricultural risks and identify appropriate responses, incorporate agricultural risk perspective into decision making, and build capacity of local stakeholders in risk assessment and management, the Agricultural Risk Management Team (ARMT) of the Agriculture and Environment Services Department of the World Bank is conducting an agricultural sector risk assessment in Senegal. The current report was developed by a team led by Stephen D'Alessandro and comprising Amadou Abdoulaye Fall, George Grey, Kersten Hell, Traci Johnson, Simon Simpkin, Kilara Suit, and Abdrahmane Wane.

The team is especially grateful to Aifa Fatimata Ndoye Niane and Vikas Choudhary of the World Bank for their support and inputs throughout the activity's planning, fieldwork mission, and report preparation. The team would also like to extend its appreciation to Maguette Diop Ndiaye of the Ministry of Economics and Finance, the Ministry of Agriculture and Rural Equipment, other government representatives, farmers, market traders, and all those who shared their perspective and insights, which provided the basis for this study and its findings.

This activity would not have been possible without the generous contributions from USAID, Ministry of Foreign Affairs of the Government of the Netherlands and State Secretariat for Economic Affairs (SECO) of the Government of Switzerland.

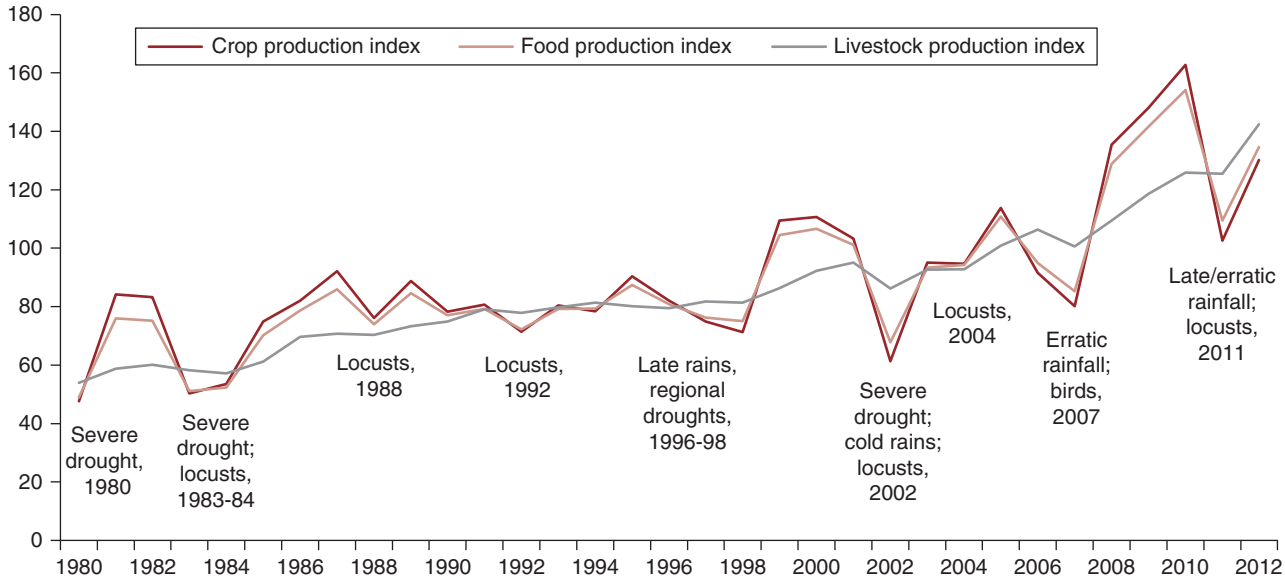
EXECUTIVE SUMMARY

Senegal's agricultural economy today accounts for roughly one-sixth of national gross domestic product (GDP), down from nearly one-quarter in the mid-1980s. Although sector output has expanded by 70 percent over the past 30 years, population growth has quadrupled. During this period, successive government policies have promoted intensification of crop and livestock production via supportive policies and public investments.[1] And yet, growth has been lackluster amid limited take-up of improved seeds and fertilizer consumption that remains among the lowest in the region. A major limiting factor has been widespread reluctance among the millions of smallholder farmers in Senegal who dominate production to assume the risks associated with increased productivity. With only limited capacity to manage these risks, highly vulnerable farmers choose to limit their exposure by limiting their outlays. Moreover, unmanaged risks have a profound impact on sector performance. A sound understanding of the risks faced by farmers and other agricultural sector stakeholders enables development of risk management systems that can at once support new productivity investments, strengthen resilience, reduce losses, and drive sector growth.

This agricultural risk assessment study was undertaken to provide a review of production, market, and enabling environment risks facing farmers and other stakeholders across Senegal's agriculture sector. The report has been compiled with extensive analysis of crop and livestock production, price, and meteorological data records over the period 1980–2012. It includes a review of key documentary evidence of yield and risk events together with input from interviews held with farmers, traders, processors and others in rural Senegal as well as with government and agricultural research staff between March and May 2014. The results of the analysis are considered in the light of the vulnerability of the different stakeholders to the effects of ex post shock events and the resulting ex ante impact upon investment. The most salient issues and results of this analysis are outlined in the text of the report. A considerable volume of supporting data is supplied in the appendixes, including (1) an analysis of cumulative rainfall during 1980–2013; (2) an assessment of levels of vulnerability among key

[1] GOS expenditures on agriculture (as a percentage of total expenditure) have exceeded 12 percent on average during the 10-year period 2000–10, well above the 10 percent commitment under NEPAD's CAADP framework.

FIGURE ES.1. TIMELINE OF MAJOR SHOCKS TO AGRICULTURAL PRODUCTION IN SENEGAL (2004–06 = 100), 1980–2012



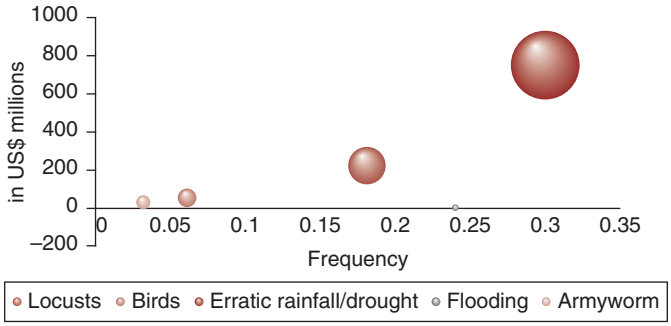
Source: World Development Indicators

livelihood groups; (3) a review of current agricultural insurance initiatives and market development options; and (4) an analysis of probable climate change impacts on crop production systems. The report's principal findings, conclusions, and recommendations are summarized below.

Figure ES.1 depicts a historical timeline of the most notable risk events that adversely affected sector performance during the period under review. At the national level, the analysis highlights agricultural production and livelihood systems that are highly vulnerable to downside risks. These most notably include erratic rainfall and drought as a more extreme but less frequent expression of the same phenomenon. Severe drought, especially in northern regions, emerges as the biggest risk in terms of estimated aggregate losses to crop and livestock—a one in every four years event on average over the review period. The analysis also suggests a corresponding increase in the frequency of floods over the same period, but with limited aggregate impact on agricultural supply chains. After drought, locust outbreaks are the second most common and costly risk affecting agricultural production. Other notable risks include price volatility and other crop pests.

Since 1980, the agricultural sector has been subject to at least 11 major production shocks, with a frequency of every three to four years on average across the 33-year

FIGURE ES.2. IMPACT AND FREQUENCY OF MAJOR AGRICULTURAL RISKS IN SENEGAL, 1980–2012



review period. The results of trend analyses indicate that for the 12 crops analyzed, the loss of production over the period was approximately 4.82 million metric tons (MT), with an estimated value of US$1.40 billion, or 3.9 percent of agricultural GDP on an average annual basis (figure ES.2). It is worth noting that this reflects only the ex post impact. The ex ante impact may be of equal magnitude or even larger. Although the average annual impact of shocks on GDP is relatively modest (less than 4 percent), actual impacts when they occur can result in losses of the order of 10 to 20 percent of sector GDP. According to the analysis, Senegalese agriculture is subject to losses exceeding 10 percent of gross production value in one out of

every five or six years on average due to unmanaged risks. Erratic rainfall and/or drought account for approximately 50 percent of crop yield reductions. Pests and diseases, especially locusts, account for a further 25 percent.

PRODUCTION RISKS

The most important factor contributing to crop and livestock production risk in Senegal is weather (figure ES.2). The key aspect of weather risk is that due to moisture stress caused either by erratic rainfall, early cessation of rains, delayed onset of rains, or extended drought. Even in the absence of these specific conditions, it has been shown that more than 40 percent of the variation in national crop yields can be ascribed simply to the variation in annual rainfall amounts. From an agricultural perspective, the geographic extent of other aspects of weather (wind, floods, and hail) is so limited that they have no discernible impact on aggregate, national-level yields.

The impact of historical and future climate change on rainfall amounts and intensities in Senegal is uncertain. Historically, national rainfall data suggest that rainfall amounts were decreasing until 1990, but since then, annual cumulative levels show an increasing trend. Although aspects of climate contribute substantially to the risk faced by producers, the anticipated impact of climate change upon that risk appears to be uncertain, the most consistently predicted trend being an increase in the variability and intensity of rainfall amounts.

The three most significant crop pests are the Senegalese grasshopper or "sauteuriaux" (*Oedaleus senegalensis*), locusts (*Locusta migratoria*), and birds (mainly quelea finch). The first two are non–crop specific whereas the third is confined mainly to sorghum and millet (although maize can also be affected). During the 33-year review period, there have been recurrent locust invasions in Senegal, with significant impact on both cash and food crops, and also affecting livestock production through loss of grazing. Damage can be highly localized, but large swarms can affect vast tracts of land. Damages due to locusts in 2004 were estimated at 2 million tons of crops, equivalent to 20 percent of the population's food needs in the Sahel region. Although all of the stakeholders confirmed that pests and diseases are one of the main risks to agricultural production, most farmers do not have the knowledge or the financial means to adequately tackle crop pests.

For livestock production, the increasing unpredictability of rainfall is a notable risk. However, erratic rainfall or even geographically limited drought is a risk among pastoralists only in the event that they are unable to migrate to more favorable pastureland. It is widespread drought, severely limiting the carrying capacity of the entire regional grazing area, which constitutes the biggest risk faced by livestock producers. Cold rainfall can have an equally devastating impact, although both occur relatively infrequently. Another noteworthy risk for livestock producers are bushfires, which according to some estimates damage as much as 6 percent of the potential dry season grazing area and destroy on average 3.8 million MT of biomass each year.

Livestock disease in general was highlighted as a risk in fewer than one of five meetings conducted, but individual diseases were mentioned more frequently. In particular, producers noted losses due to Rift Valley fever, highly pathogenic avian influenza, and Newcastle disease. These three diseases are considered to be among the three most important livestock production risks. Avian influenza and Rift Valley fever are also considered as market risks as they both can have a large impact and influence on both local and international trade.

Notably, other diseases such as foot and mouth disease (FMD) and contagious bovine pleuropneumonia (CBPP) could be considered as major risks if the response mechanisms required for control and eradication were actually put in place. This would require the quarantining and slaughter of whole herds, which would have a major impact on the whole livestock industry. Currently, however, the government implements less extreme control measures and although there are some losses in productivity, the impact is relatively limited.

MARKET RISKS

Among market risks, price volatility for both food and cash crops and livestock was assessed through the statistical analysis of both domestic and international time-series

data. The analysis found considerable variability of domestic food crop prices together with limited variability of domestic cash crop prices. International prices of rice, maize, groundnut oil, and cotton were more variable, with coefficients of variation exceeding 40 percent in some cases. The analysis suggested that companies that process locally purchased commodities for export (that is, cotton, groundnuts) face a significant price risk because the domestic purchasing price may vary independently of the export price, as a result of both the local price setting mechanism. Although exchange rate fluctuations can also contribute to price risk for exporters of locally purchased products, the exchange rate of the CFA franc (XAF) to the U.S. dollar has shown only modest variability over the past 12 years.

The impact of price risk varies substantially according to the crop and its importance to the rural economy. The price of staple crops at this time is critical to household food security and the risk that increased food prices might reduce the accessibility of food has a substantial impact on household resource management. It is the profoundly negative ex post impacts of these fluctuations upon nutrition, health, and survival that result in staple food price shocks as being listed as the highest priority risk faced by rural households. Because few producers grow cash crops without first securing their own supply through staple crop production, the ex post risks to nutrition, health, and survival caused by fluctuations in cash crop prices tend to be less pronounced. As a result, ex ante risk impacts are also reduced. This may be less the case for producers of horticultural crops who are exclusively oriented toward the market and who are often exposed to higher levels of price volatility. More generally, price risk for cash crops is visited mainly upon the buyers of commodities, although price fluctuations can contribute significantly to the risks faced by all stakeholders in cash crop subsectors.

Traditionally, the limited reliance of pastoralists upon markets implied a limited impact of price risk upon pastoral livestock production, but this situation is changing. Livestock prices often plummet while food prices increase; this is now a common shock-induced pattern in dry lands and a major risk for livestock owners. Within the poultry sector, volatility in price of imported feed components, notably corn and soya, which contribute 80 percent of poultry feed, is considered a major source of risk.

ENABLING ENVIRONMENT RISKS

When ranked in terms of impact and frequency, a key risk noted within the livestock sector is derived from uncertainty over land tenure and access. As noted above, access and mobility are critical to pastoral livelihoods. The analysis indicates that inconsistent policy making and implementation of regulations can weaken traditional coping mechanisms and increase vulnerability levels among extensive pastoralist communities, particularly in the north where land use pressures are increasing. Similar uncertainty is derived from the inconsistent delivery of animal health services, including the enforcement of policies on vaccination, quarantine, and movement.

Where conflict occurs, unrestrained by the rule of law, then the impact of risk, both ex post and ex ante, is considerable. Such risk has been widespread in Casamance, where growers limit both the area and the level of investment applied to crop production. Impacts on wealthier livestock owners who own larger herds can be substantial, with more than 60 percent losses being reported in some cases. Conflict and tensions between herders and crop growers, particularly in the north, were highlighted as risks by several interlocutors during the course of the study. In addition, anecdotal evidence would suggest that the conflict in northern Mali has destabilized Senegalese livestock markets in recent years and contributed to higher levels of price volatility.

VULNERABILITY

Understanding levels of exposure to different risks and of mitigation and coping capacity among the various livelihood groups can help decision makers better target interventions. Among livelihood groups, nomadic pastoralists manage weather risks by continually moving to fresh grazing grounds. However, growing land pressures place strains on their mobility and their access to sufficient grazing and water, and thus their capacity to cope. Agropastoralists tend to be among the poorest households, which typically lack the resources needed to absorb shocks,

and exhibit the highest levels of vulnerability. The risk of inadequate moisture renders dry land smallholders more vulnerable to production risk than their irrigated counterparts and this is reflected in the lower levels of inputs applied to dry land crops. The extent to which intensive livestock producers are more or less vulnerable to risk than their extensive counterparts is debatable. On balance, it would appear that although the impacts of risk events upon intensive livestock production may be greater than those experienced by extensive producers, most intensive producers have a greater capacity both to prevent such events and to withstand their impacts.

Commercial farmers face many of the same risks as do smallholders, but their levels of vulnerability differ. Commercial producers may be able to absorb more production risk, but face greater price risk. Processors are vulnerable to market risk because of increased local prices and/or reduced costs of competing imports. Cotton and groundnut processors are also vulnerable to the risk of aflatoxin contamination, which cannot be detected in the unprocessed materials but which can render the final products unmarketable if subsequently detected. Processors also face the risk of inadequate supplies as a result either of poor production, or of a redirection of inputs toward food crops for own consumption, especially after a poor harvest. Traders are primarily vulnerable to risks caused by market uncertainty. In particular, they can have poor knowledge of market volumes or of the extent of production. As a result of this vulnerability, few traders are willing to accumulate large positions with the intention of selling at higher prices.

RISK MANAGEMENT

The government of Senegal (GOS) understands the importance of putting in place effective agricultural risk mitigation systems. It has adopted in recent years a range of capacity-building measures toward reducing Senegal's exposure to natural disasters and impacts from a changing climate. These measures include the creation of the Directorate of Civil Protection (DPC), the development of a National Platform for Disaster Risk Reduction (DRR), and the elaboration of a National Action Plan on DRR (2010–15). Senegal also participates in the recently launched, EU-led Global Alliance for Resilience Initiative (AGIR), a regional response to chronic food and nutritional insecurity across the Sahel, and is an active member of the Comité Permanent Inter Etats de lutte contre la Sécheresse dans le Sahel (CILSS). In 2006, Senegal finalized its National Adaptation Programme of Action (NAPA) for climate change adaption. Following 2011's severe drought affecting northern pastoralists zones, GOS set up emergency feed stocks under its *Operation sauveguard du betail*. Such GOS initiatives are already helping to safeguard livelihoods, promote climate adaptation, and strengthen household resilience. And yet, as highlighted by this report, agricultural supply chains in Senegal remain highly vulnerable to a wide range of risks that jeopardize rural livelihoods. The current study highlights the need for a more targeted and systematic approach to agricultural risk management in Senegal.

Based on an analysis of key agricultural risks, an evaluation of levels of vulnerability among various stakeholders, and the filtering of potential risk management measures, this assessment makes the following recommendations for GOS's consideration. The proposed focus areas of intervention encompass a broad range of interrelated investments, which together hold strong scope to improve agricultural risk management and strengthen the resilience of agricultural systems in Senegal.

1. Strengthening extension delivery systems (for example, face-to-face, farmer-driven, ICT-based [Information and Communication Technology]) for improved farmer access to technology and agronomic advice on improved soil, water, and pest management practices (for example, conservation agriculture, integrated pest management [IPM]).
2. Promoting improved water management measures (for example, water pans, roof and rock catchment systems, subsurface dams) and microirrigation technology (for example, drip irrigation) via community-led initiatives (for example, cash/food for work programs).
3. To further reduce rainfall dependency and better exploit existing water and land resources, promoting expansion of irrigation infrastructure.
4. Promoting use of contour erosion and fire barriers, cisterns for storing rainfall and runoff water, controlled/rotational grazing, grazing banks,

homestead enclosures, residue/forage conservation, and other Sustainable Land Management (SLM) practices to reverse degradation of water, soil and vegetation cover ensure sustainable access to grazing land.

5. Establishing and improving regional and national normalized difference vegetation index (NDVI) and early warning systems and farmer training linked to an effective and early emergency response system for drought and locust outbreaks.
6. To improve decision making among farmers and pastoralists and attenuate price volatility, strengthening the quality and access to needed agro information, including weather forecasting, extension advice and innovations (that is, seeds, water management), input/output prices, and so on for improved decision making.
7. Strengthening seed distribution systems, vaccination programs, and animal health services through improved monitoring and enforcement of existing quality control regulations governing product and service delivery, institutional capacity-building, reform measures, and so on.
8. Building resiliency in northern pastoralist zones via more broadly inclusive policy making around land administration for improved mobility and access, and development of community-driven feed/fodder production and storage centers.

CONCLUSION

This Phase I assessment assesses agricultural risks and impacts during the period 1980–2012. By documenting and analyzing how Senegal's agricultural economy has been affected in the past by risk events, the study has generated insight into which sources of risks are most likely to affect the sector and dependent livelihoods in the future. By prioritizing risks, the study can help GOS focus attention and resources on a smaller set of key risks that are having the most adverse impacts on production yields, incomes, and livelihoods. The study suggests a framework for the development of a more comprehensive, integrated risk management strategy to strengthen and broaden existing mitigation, transfer, and coping measures in Senegal. Finally, it provides a filtering mechanism to aid in the selection of a set of strategic interventions for improved agricultural risk management.

The assessment recognizes that many of the proposed strategies may already be covered to varying degrees under existing risk management programs. Others may currently be in the process of implementation, either by government agencies or by donors. Moving forward, the Phase II Solutions Assessment will analyze the effectiveness of existing programs, identify and assess challenges impeding their effectiveness, and outline strategies for scaling up effective interventions to reach a larger number of beneficiaries. This follow-up activity will place strong emphasis on ensuring a more coordinated, integrated approach to risk management in Senegal to ensure more effective and meaningful risk reduction and resilience building across the sector.

It is hoped that the findings and conclusions of this assessment will help to contribute to the existing knowledge base regarding the agricultural risk landscape in Senegal. It is also hoped that the study will help to inform a dialogue moving forward between the GOS, the World Bank, and GOS's other development partners that will lead to concrete interventions toward improved agricultural risk management and stronger resilience among stakeholders in the years ahead.

CHAPTER ONE
INTRODUCTION

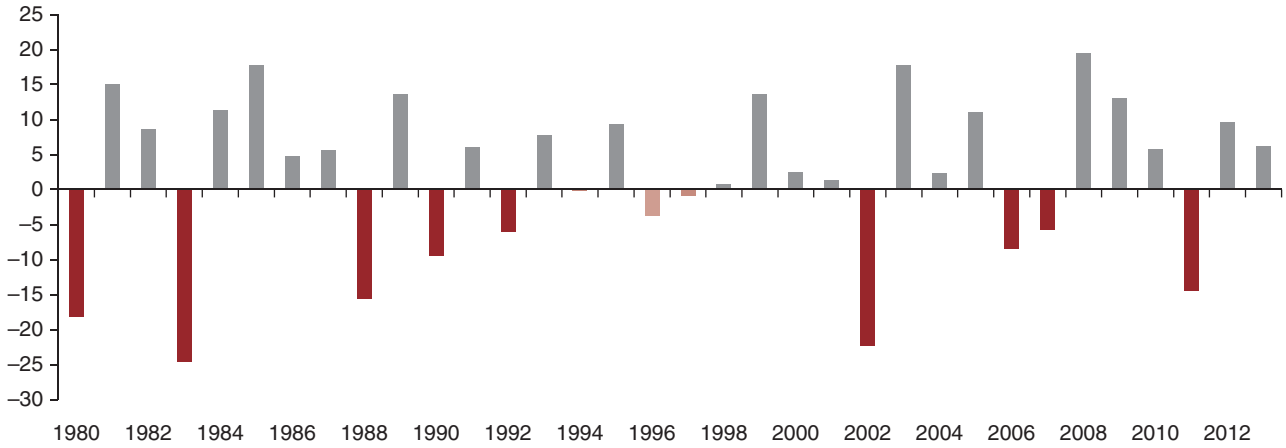
Risks are a pervasive and permanent fixture of the agricultural landscape. They are also costly. Unchecked, they breed uncertainty and stifle investments. For a given rate of return, the higher the risk associated with an agricultural enterprise, the lower the level of investment that it can attract. On the aggregate, this can have a debilitating impact on sector growth. This is especially true when risk is amplified by a limited capacity to absorb shocks. When risks do manifest, they can cause substantial losses to income and assets—especially among the most vulnerable communities—placing livelihoods, and in extreme cases, sector growth, in jeopardy. Failing to address agricultural risk can severely hamper long-term economic growth and poverty reduction efforts.

The performance of Senegal's agricultural performance exemplifies the impact of unmanaged risk on productivity among vulnerable smallholder crop producers and pastoralists. Despite the fact that well over half (57.1 percent in 2012) of the population lives in rural areas and derives some portion of its livelihood from agriculture, the sector itself contributes less than one-fifth (16.7 percent in 2012) to GDP, according to the World Bank. Despite several years of strong performance, sector growth has averaged 2.3 percent since 1980, amid notable volatility in year-on-year performance (figure 1.1).

A succession of agricultural strategies designed to increase productivity has largely failed to intensify production beyond a subsistence level, and much of the country, although suitable for agriculture, remains underdeveloped. Keeping risks in check, shielding the most vulnerable, and building resilience among all agricultural stakeholders to better withstand and recover from inevitable shocks requires moving from ad hoc interventions to proactive, systematic and sustained risk management.

The government of Senegal has historically responded to drought and other shocks with direct financial support to farmers as well as general assistance to the rural population. More recently, GOS put in place a series of emergency response and financial mechanisms to help affected communities better cope with shocks and enhance flows of rural credit. These include the Fonds de Bonification, Fonds de Garantie, and the

FIGURE 1.1. AGRICULTURAL, VALUE ADDED (ANNUAL % GROWTH), 1980–2013



Source: World Development Indicators.

Fonds de Calamité. The newly launched Operation de Sauvegarde du Betail organizes distribution of feed supplements to protect at-risk, breeding livestock (for example, lactating females, calves) when access to sufficient grazing is constrained. In 2014, Senegal was one of five countries to subscribe to a new pan-African drought index insurance facility under the Agricultural Risk Capacity (ARC) initiative. Important as these and other initiatives are, GOS recognizes that these efforts alone are insufficient to insulate agricultural supply chains and the livelihoods they support from adverse shocks.

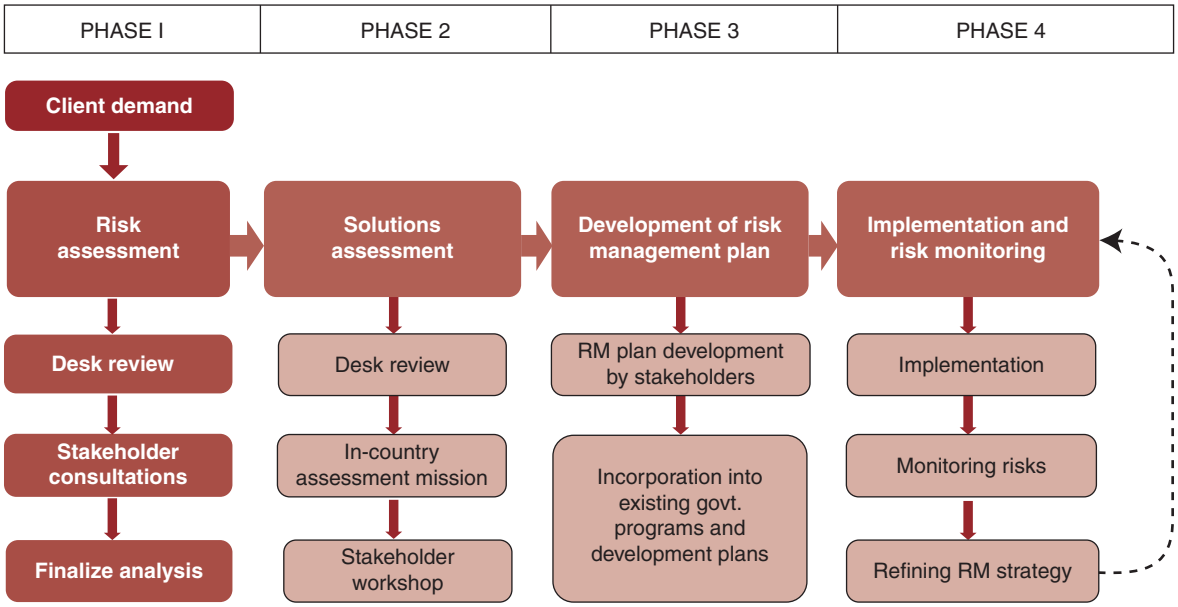
It is within this context that the World Bank, with support from the G-8 and the USAID and in collaboration with the Ministry of Agriculture and Rural Equipment (MARE), commissioned the present study. The objective of this assessment was to assist the government of Senegal to (1) identify, analyze, quantify, and prioritize principal risks (that is, production, market, and enabling environment risks) facing the agricultural sector; (2) analyze the impact of these risks; and (3) identify and prioritize appropriate risk management (that is, mitigation, transfer, coping) interventions that might contribute to improved stability, reduced vulnerability, and increased resilience of agricultural supply chains in Senegal. This report presents a summary of the assessment's key findings.

METHODOLOGY

The analysis presented in this report is based on a methodology for assessing risks in agricultural supply chains. The methodology was designed by the Agricultural Risk Management Team of the World Bank. It offers a conceptual framework and set of detailed guidelines for conducting a more systemwide assessment of risk, risk management, and vulnerability within agricultural supply chains. The methodology contains logical steps within four consecutive phases (figure 1.2). Phase I, for which this study is the primary deliverable, focuses on identifying, quantifying, and prioritizing the major risks that cause adverse shocks to the sector.

Following in-depth analysis of historical, time series rainfall, crop and livestock production, pricing, and other baseline data, the Assessment Team conducted broad-based, in-country consultations with stakeholders during March 2014. These included individual farmers, farmer groupings, input suppliers, market traders, food processors, and representatives of the government and research and academic institutes in and around Dakar and in key agricultural production zones across Thies, Fatick, Diourbel, Kaolack, Kaffrine, Louga, and St. Louis. The mission team organized a wrap-up roundtable consultation hosted by the Ministry of the Economy and Finance (MEF) on March 21 to share preliminary results and solicit feedback. Participants were asked to prioritize possible future interventions by ranking a long list of risk mitigation, transfer, and coping interventions. Their input provided valuable insights into GOS priorities and all feedback has been incorporated into the study's analysis and findings.

FIGURE 1.2. AGRICULTURAL SECTOR RISK MANAGEMENT PROCESS FLOW



Source: World Bank.

The results of this assessment will provide the conceptual basis for Phase II, which will focus on identifying priority solution areas and related risk management interventions best suited to managing the priority risks identified. By the end of this activity, the World Bank—in close collaboration with GOS, its donor partners, and other sector stakeholders—will develop and validate a matrix of priority interventions related to risk mitigation, transfer, and coping within a comprehensive and systematic risk management framework. It is hoped that the outcome of this assessment will serve to inform ongoing and future GOS sector policy and planning, which will secure improved sustainability of agricultural investments and enhance long-term agricultural resilience and growth.

RATIONALE

The rationale behind the risk prioritization exercise is based upon the nature of risk in agriculture. There is no standardized procedure for the quantification and measurement of agricultural risk. Although it is possible to measure the ex post impacts of events that contribute to risk in terms of the loss of yield or income resulting from those events, it is far more difficult to estimate income foregone by producers, traders, and others who limit their investments because perceived risks associated with the production and marketing of a specific crop or animal. Such ex ante impacts of risk might be quantified as potential losses, but their attribution and measurement are extremely complex.

This analysis focuses mainly upon the ex post impacts of adverse events associated with risk. Ex ante impacts of risk upon investment decisions are largely ignored. The measurement of perceived risk and associated impacts upon investment decision making is a complicated task that goes beyond the resources available in this preliminary assessment. Elbers, Gunning, and Kinsey (2007) proposed that ex ante impacts of risk upon agricultural GDP (in terms of foregone production) are potentially as great if not greater than ex post impacts from risk events. This assessment is based on the premise that ex ante impacts can reasonably be expected to be roughly proportional to ex post losses. Thus, after taking into account the qualitative input from interviews and focus groups, the priority components of risk can be readily identified and responses recommended. A more detailed justification of the methodology is given in appendix F.

Chapter 2 of the report provides an overview of the agricultural sector in Senegal and a discussion of key growth constraints. This is followed by an assessment of the main

agricultural risks (that is, production, market, enabling environment) in chapter 3. Chapter 4 analyzes the frequency and severity of highlighted risks and assesses their impact. Chapter 5 presents some stakeholder perceptions of risks and evaluates levels of vulnerability among various livelihood groups. The study concludes in chapter 6 with an assessment of priorities for risk management and a broad discussion of possible risk management measures that could help to strengthen the resiliency of agricultural supply chains and the livelihoods they support.

CHAPTER TWO
AGRICULTURAL SYSTEMS IN SENEGAL

To inform the analysis and discussion of agricultural risk in Senegal, this chapter presents an overview of the country's agriculture sector. The most pertinent sector characteristics related to risk are given particular attention. The analysis primarily covers the 33-year period from 1980 to 2012 to assess the frequency and severity of the most important risks.

AGRICULTURE SECTOR IN SENEGAL

Table 2.1 shows the key economic indicators for Senegal with notable import to agriculture. Of particular relevance is the fact that while approximately 57.1 percent[2] of the population lives in rural areas and is largely dependent upon agriculture, over the five years up to 2012, agriculture and associated activities generated only 16.7 percent of national GDP, according to the World Bank's World Development Indicators. Considering the current GDP of US$14.05 billion and a population of 13.73 million, it is evident that there is considerable discrepancy in rural vs. urban incomes. Whereas per capita GDP may be US$1,023, the average per capita value added for the population dependent upon agriculture is US$300; the rest of the largely urban population is 6.7 times higher (US$2,000). This is due largely to the relatively low output of the country's agricultural production systems, which generate less than US$1.00 per capita per day. This suggests that the bulk of agricultural activity is of a subsistence nature.

In fact, the level of production is inadequate to meet national demand and Senegal imports significant volumes of food. Food imports in 2012 were worth US$1,546 million, or 11 percent of GDP and up to 26 percent of total imports by value, according to the World Bank. Senegal's exports are valued at slightly over 50 percent of total imports and the current account is balanced largely through a combination of remittances and development assistance.

[2] According to the World Bank, Senegal has one of the highest levels of urbanization in Africa, estimated at 42.9 percent in 2012 and growing at a rate of 3.6 percent per year.

TABLE 2.1. SENEGAL NATIONAL AND AGRICULTURAL STATISTICS, 2012

National		Agricultural	
GDP (Current US$ million)	14,050	Total land area (ha)	19.25 million
Population (million)	13.73	Total agricultural area (ha)	9.51 million
Per capita GDP (Current US$)	1,023	Arable area (ha)	1.27 million
Per capita GDP (US$ PPP)	1,906	Cereal crop area (ha)	3.85 million
Population growth rate (%)	2.9	Permanent cropped area (ha)	58,000
GDP growth rate (%)	3.5	Arable land per person (ha)	0.29
		Forest area (ha)	8.43 million
Contribution to GDP:		Avg. cereal yield (kg/ha)	1,310
Agriculture	17%	Avg. fertilizer use (kg/ha)	7.6
Manufacturing	14%	Cereal production (MT)	1.66 million
Other industry	10%	Cereal demand (MT)	2.48 million
Services	59%		
Imports (Current US$ million)	5,901		
Exports (Current US$ million)	3,372	Shoats (head)	10.93 million
Remittances (million)	1,478 (2005)	Pigs (head)	375,000
Net ODA (Current US$ million)	1,084	Camels (head)	5,000
Foreign Direct Investment (US$ million)	338		
Inflation (yr on yr CPI basis)	1.4%		
Poverty headcount (national poverty line)	46.7% (2011)		
Gini Coefficient (income)	40.3		

Source: World Bank, FAOSTAT.

AGRO-CLIMATIC CONDITIONS

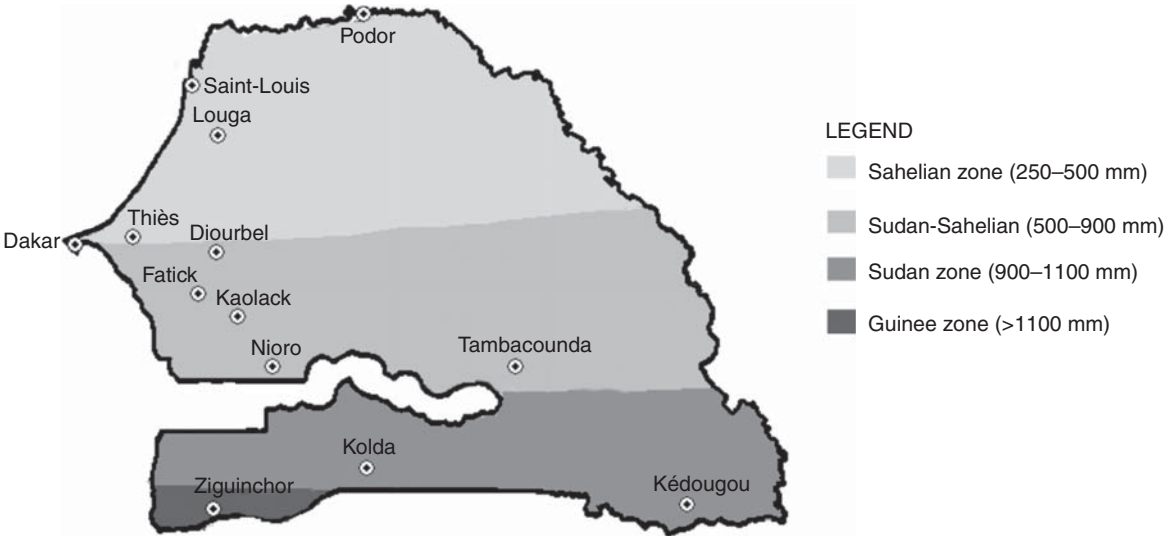
Senegal has four climatic zones (figure 2.1). They are characterized by varying levels of rainfall and temperature with conditions that gradually become increasingly dry moving north from Senegal's high rainfall southern regions to its northern arid zones.

All zones have unimodal rainfall. The length of the rainy season differs from one year to the next and from one region to the other, being longer in the south (figure 2.2). With less than 1 percent of agricultural land under irrigation, the growing season in Senegal strongly correlates to the rainy season. This strong dependence of crop production on rainfall results in highly variable production, as both rainfall amounts and the onset and cessation of the rains are subject to marked space-time variability and temporal changes. Tables G.1 and G.2 in appendix G compare cumulative rainfall amounts across 25 weather stations for which consistent and reliable information was available for the period 1980–2013.

LAND AND WATER RESOURCES

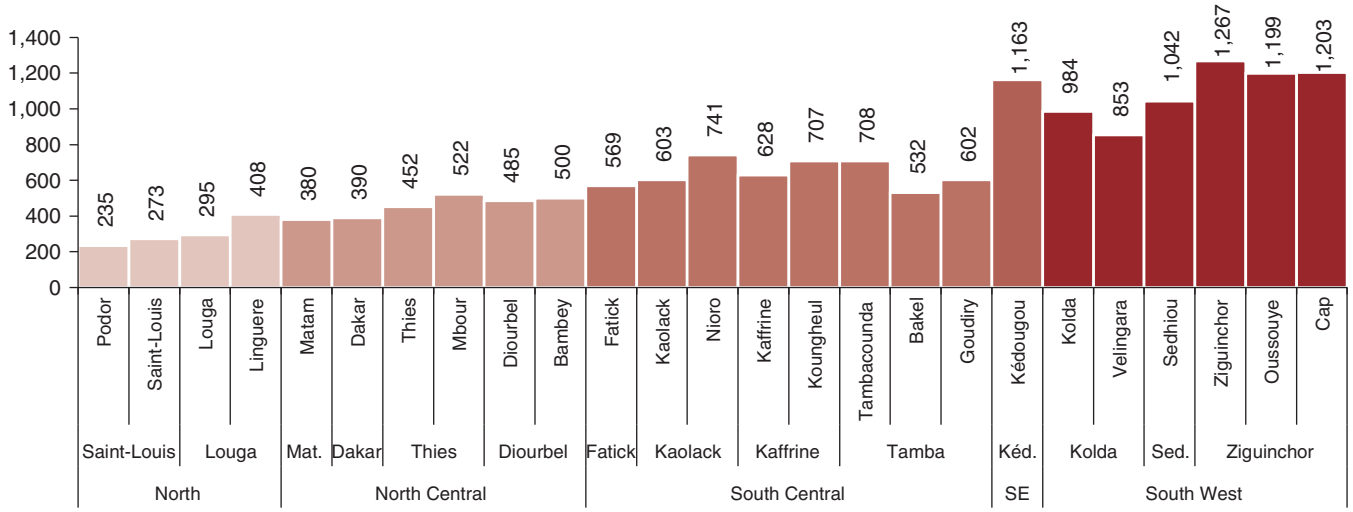
Senegal is a flat country within the Senegal-Mauritanian Basin. Elevations above 330 feet (100 meters) are found only on the Cape Verde Peninsula and in the southeast. The country is drained by the Sénégal, Saloum, Gambia (Gambie), and Casamance rivers. Water resources are estimated at over 35 billion cubic meters, of which 31 billion are renewable surface water and 4 billion cubic meters are groundwater. However, the flat topography is for the most part unsuitable for the impoundment of water, limiting the potential for irrigation in many regions. The Senegal River Valley alone accounts for an estimated 240,000 ha of irrigable land, of which about 110,000 is

FIGURE 2.1. CLIMATIC ZONES OF SENEGAL



Source: ISRA, adapted.

FIGURE 2.2. AVERAGE ANNUAL RAINFALL BY REGION, 1980–2013



Source: ANACIM.

either currently under irrigation or is in development. Some irrigation has also been developed in Casamance in the south.

Although Senegal has over 19 million ha of land, over half of this is undeveloped bush and arid land used for livestock grazing; the total agricultural area is 9.5 million ha of which 3.9 million hectares is suitable for arable crops. Of this, 40 percent is regularly cultivated (that is, 20 percent of the total agricultural land area is used for seasonal crop production). Though much of the arable area receives rainfall that is sufficient to produce average yields, roughly one-tenth of this area receives average annual rainfall values below 500 mm, effectively limiting production.

The soils of Senegal are highly diversified. They include fertile valley soils near the Senegal and Saloum rivers, sands suitable for groundnuts, and sandy clays that can support other crops in the western and eastern areas. In the south and center of the country, poor lateritic soils predominate, whereas in the Casamance region, crops can be grown on the more fertile clay soils. In almost all cases, however, the soils are vulnerable to degradation and fertility levels are declining as cultivation pressure increases.

AGRO-ECOLOGICAL ZONES

Senegal has six agro-ecological zones, based on biophysical and socioeconomic criteria: (1) the Niayes; (2) the Senegal River Valley; (3) the Sylvo-pastoral Zone; (4) Groundnut Basin; (5) Eastern Senegal; and (6) Casamance (figure 2.3). Each zone is a natural region, with its own potential and vulnerability to ecological and weather-related hazards:

- **Niayes** is a 5 to 10 km strip covering 2,759 km^2. It is the major commercial vegetable-producing area in Senegal. It is a densely populated area and faces challenges of soil and water salinity and coastal erosion.
- The **Senegal River Valley** covers a surface area of 9,658 km^2 in the north of the country bordering Mauritania. This zone is characterized by alluvial plains and sandy uplands. Rain-fed farming is almost nonexistent in the delta, and most agricultural production is derived from irrigation. Some areas are subject to salinity, but much of the mid-river area has a high level of fertility due to regular flooding.
- The **Sylvo-pastoral** zone covering 55,561 km^2 is Senegal's major cattle-breeding area and is mainly populated by nomadic Fulani ethnic groups.
- The **Groundnut Basin** of 46,367 km^2 is highly populated and subject to ecosystem degradation and depletion of land resources (soil fertility and timber resources). In addition, soil regeneration has slowed as a result of upland soil acidification and lowland salinity.
- The **Eastern Senegal** zone of 51,958 km^2, is subject to rampant rural poverty due to heavy population pressure on natural resources, despite its strong agro-pastoral potential.
- The **Casamance** can be divided into three zones—the lower, middle, and upper. With a total surface area of 28,324 km^2, the region is characterized by lowland soil acidification, water erosion, loss of forest diversity, increased salinity, acidity, iron toxicity, and acute mangrove degradation within the Casamance estuary.

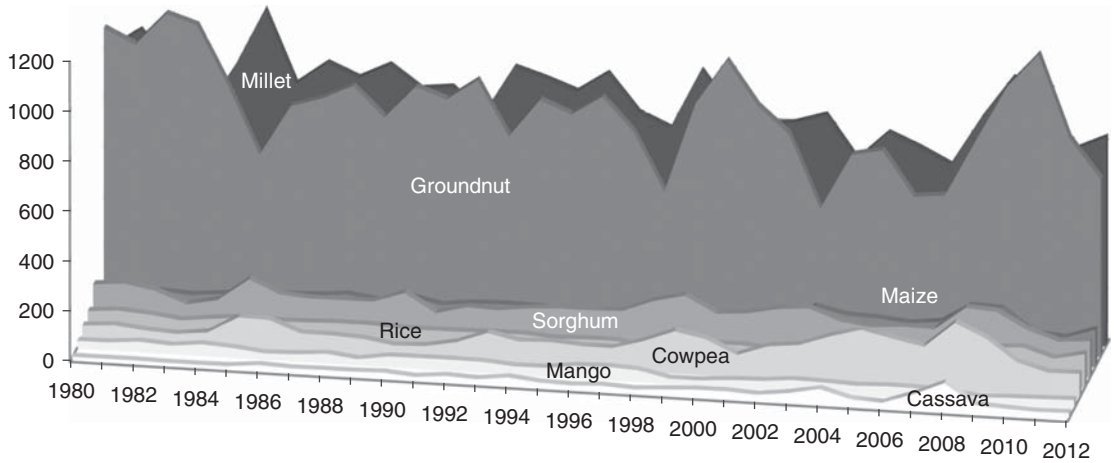
CROP PRODUCTION SYSTEMS

Although Senegal encompasses more than 19 million ha, the area available for agriculture is limited by poor soils and climate to less than 10 million ha (table 2.1). Forty-three percent of the land area remains as undeveloped bush available for grazing, whereas a significant proportion of the remainder receives less than 500 mm of rainfall so that yields are severely constrained and much of the agriculture that is undertaken is inadequate even for subsistence. Shifting cultivation is commonly practiced and substantially less than 50 percent of the arable area is cropped at any one time. Crop composition has varied little over the past 30 years (figure 2.4). Where there is adequate moisture, the main crops cultivated are groundnuts and millet, which together account for almost 75 percent of the planted area. Maize, rice sorghum, cowpeas,

FIGURE 2.3. AGRO-ECOLOGICAL ZONES IN SENEGAL

Source: Adapted from Directorate of Water, Forests and Hunting Conservation.

FIGURE 2.4. TRENDS IN CROP PRODUCTION AREA HARVESTED (thousand ha), 1980–2012



Source: FAOSTAT.

and cotton make up about 25 percent and less than 1 percent is sown to other crops, including vegetables.

Senegal experiences a variable climate with low levels of rainfall (< 600 mm per year) over much of the northern part of the country. Its soils are for the most part sandy and acid so that levels of agricultural production are generally low. The agricultural sector has been traditionally dominated by two cash crops (groundnuts and cotton) produced for the export market, although many producers also focus on the production of staple crops for their own subsistence. Nevertheless, food crop production does not meet national demand, and the country is regularly obliged to import substantial volumes of rice (1–1.2 million MT in recent years) and wheat.

Crop production in Senegal essentially comprises three categories of producers, though there is increasing diversity across both food and cash cropping systems:

- Subsistence smallholders who produce occasional commercial surpluses for sale, but undertake other income-generating activities to sustain their livelihoods.
- Commercial smallholders whose livelihood depends upon the sale of cash crops, but who often produce some crops for their own consumption.
- Pure commercial producers whose livelihood is based upon the sale of cash crops and horticulture.

TABLE 2.2. TRENDS IN CROP PRODUCTION, 1980–2012*

	Area Change (%)	Production Change (%)	Yield Change (%)
Food Crops			
Maize	108.9	230.2	54.2
Rice	39.6	99.9	359.9
Millet	2.6	44.3	42.8
Sorghum	65.6	52.4	8.3
Cowpeas	227.4	271.1	7.7
Cash Crops			
Tomatoes	486.6	647.5	23.9
Potatoes	−7.5	38.9	43.1
Cotton	−14.7	7.5	26.3
Groundnuts	−10.0	23.1	36.2
Onions	235.7	438.3	66.2

Source: FAOSTAT.
*Five-year average, 1980–84 vs. 2008–12; for onions and tomatoes, 2012 was not available, so 2007–11 averages were used.

Table 2.2 shows levels of variation in cropping area, yield, and total output for each of the main food and cash crops during the period 1980–2012. In terms of output, tomato and onion production have grown the most during the review period, followed by cowpeas, maize, and rice. Much of this growth has come from the expansion of cropping area, with the exception of rice production, which has benefited from a near quadrupling of yields (359.9 percent) during the 33-year period. Production of

tomatoes and onion, and to a lesser extent, cowpeas and maize, has seen the most marked growth.

FOOD CROPS

Millet and Sorghum

Millet and sorghum are the traditional cereal crops of Senegal. Millet (chiefly pearl millet) is the most widely cultivated of the two and a large number of landraces adapted to different conditions are grown throughout the country. The crop is grown almost exclusively in monoculture in rotation with groundnuts or cowpeas. Production covered over 800,000 ha in 2012, or roughly 36.1 percent of total harvested area. The coarse grain is well adapted to moisture stress and is grown on a low input basis that is well suited to meeting smallholders' subsistence needs, for which the bulk of the crop is produced. Higher yielding varieties have been produced by Institute Sénégalais de Recherches Agricoles (ISRA) and are being increasingly used by farmers, but production is still inadequate to meet demand.

Sorghum is also drought tolerant, and although it yields more heavily than millet (960 kg/ha in 2012), the crop requires higher levels of fertility and deeper soils than millet, and it is indicative of the conditions in much of Senegal, that the area and production of sorghum at 143,000 ha and 137,000 MT respectively are less than 20 percent of millet. Sorghum tends to be grown in wetter areas of the country to the south where it tends to replace millet in the rotation. Traditional landraces adapted to a range of conditions exist, but improved varieties are available and are used by approximately 45 percent of smallholders. Sorghum is also grown on a low input basis as a subsistence crop, most of which will be consumed by the households producing it. Although millet and sorghum are well adapted to the edaphic and climatic conditions of Senegal, both are regularly subject to depredation by birds (quelea finch) and parasitism by Striga.

Cowpeas

Cowpeas exhibit more drought tolerance than do groundnuts. The crop also has a particular advantage in Senegal; it can be eaten early as near-mature green pods as well as harvested dry. Cowpeas can thus provide food during the traditional "hungry gap period." The crop is grown in monoculture throughout most of the country, with the exception of the Groundnut Basin, where it is often replaced in the rotation by groundnut. Cowpeas require few inputs, and as a legume fixes nitrogen, enhancing the fertility of the soil for subsequent crops of millet or sorghum. The short growing period of most cowpea varieties is a key factor in their capacity to avoid moisture stress, but it also results in lower yield. Senegal contains many local landraces of cowpeas and modern, higher-yielding varieties are also available. Nevertheless, yields in 2012 were only 425 kg/ha and production at 55,000 MT remained substantially below demand.

Rice

Rice was not traditionally a staple in Senegal. However, inadequate production of millet and sorghum has led to increased consumption of imported rice and a substantial increase in domestic production to meet the growing demand. Rice is produced under both irrigated and rain-fed conditions. Irrigated production, primarily in the northern River Valley, occurs twice a year and accounts for roughly 45 percent of harvested area. Rain-fed rice is produced either in small lowland basins or as upland rice, which constitute 42 percent and 7 percent of area harvested, respectively (the balance being mangrove production). The crop is produced mainly in the Senegal River Valley and Casamance regions. Rain-fed rice is produced almost exclusively by smallholders, whereas dry land rice in particular is produced mainly under slash-and-burn conditions with minimal inputs. Lowland rice is produced more intensively. A significant proportion of the irrigated rice is produced under commercial conditions. A number of improved varieties are available for irrigated, basin, and upland cultivation and have contributed to the 360 percent increase in yield observed over the past few decades.

CASH CROPS

Maize

Like rice, maize is not a traditional Senegalese staple. Today, it is produced as much as a cash crop as it is for household consumption. Production occurs in most agro-ecological zones, with the exception of the Silvipastoral zone. It is especially grown in the Groundnut Basin (where it is rotated with groundnuts), Casamance, and increasingly in Eastern Senegal. Both smallholders (1 to 2 ha, 90 percent) and larger

commercial growers (20 to 50 ha, 10 percent) cultivate maize. The crop is entirely rain fed. As much as 97 percent of production involves improved varieties (ASTI 2009) and most are short-season varieties (90 days to maturity).

Although the area planted has varied moderately between 100,000 ha and 200,000 ha over the past 10 years, yields have fluctuated considerably and total production has thus varied between 400,000 MT in 2005 and 110,000 MT in 2011 (see figure D.3 in appendix D). There is a growing demand for maize for both livestock feed (65 percent of production) and as maize flour (approximately 100,000 MT). The shortfall is currently met by imports that have averaged 100,000 MT in recent years. To reduce reliance on imports, the government has subsidized the costs of maize crop inputs and promoted the provision of finance for their purchase. Average maize yields in 2010–12 are somewhat lower than those in 2003–05, suggesting that although producers have increased the area planted to maize, they have not increased the intensity of production.

Groundnuts

Groundnuts are grown throughout Senegal, except in the Silvipastoral zone, and especially in the Groundnut Basin. They are grown both as a staple for household consumption and, more important, as a cash crop that can be sold on the domestic market, mostly for processing into oil for export. The crop is grown almost exclusively by smallholders. The high cost of seed is offset by a government subsidy and by input credit available through local cooperatives. However, the availability of good-quality seed is still inadequate. Yield are variable and range from 550 to 1,200 kg/ha. Production reached a peak in 2010 of over 1.2 million MT, but has declined by about 40 percent since that time. The processed groundnut oil is Senegal's main agricultural export. Groundnuts are potentially susceptible to aflatoxin contamination, but the frequency of this in Senegal is low. The production of groundnuts is considered politically sensitive and the crop is well supported by ISRA plant breeding programs and public extension. Nevertheless, groundnut production remains particularly susceptible to erratic rainfall.

Cotton

Cotton is produced mainly in Eastern Senegal. The crop has been in decline since the collapse of the country's textile production subsector at the end of the last century. Nevertheless, production expanded in 2012 as a result of a substantial increase in the price of cotton lint on the world market in 2011, although prices have since reverted to normal levels. The crop requires little fertilizer, but is nevertheless expensive to grow, because as many as five applications of insecticide may be required. Although cotton is less sensitive to moisture stress than many crops, yields have trended downward over the past 10 years.

Onions

Onions are produced as a cash crop mainly by smallholders in the Niayes agro-ecological zone. The crop is grown with supplementary irrigation and average yields are among the highest in the region. The crop requires fertilizer but few chemical inputs, and given adequate irrigation, is subject to little production risk. The crop is produced between March and July, with the majority of the crop being harvested in May and June. Because of a lack of drying and storage capacity, the market is typically saturated with onions during these months.

Tomatoes

The country has a good climate for horticultural production throughout the year. About 70 percent of Senegal's exports to the EU are green beans, cherry tomatoes, mangoes, and melons. The labor-intensive vegetable and fruit industry employs more than 17,000 families in rural Senegal. Mangoes, green beans, and industrial tomatoes are among Senegal's major horticultural crops. Tomatoes are produced under irrigation in peri-urban areas within the Niayes zone. The crop is predominantly cherry tomatoes, grown in greenhouses or under shade netting for the European market, a requirement that places it beyond the capacity of most smallholders. Production primarily takes place during the months March–May. The crop is highly perishable and the domestic market can be saturated with second grade produce during these months. Average yields fluctuate considerably from one year to the next, ranging from 52 MT/ha in 2003 to 18 MT/ha the following year, largely the result of insect pests and market demand.

Potatoes

Potatoes are also predominantly grown in the Niayes zone by smallholders. The crop is grown between March and

July and may be provided with supplementary irrigation when necessary. Yields generally vary about 15–25 MT/ha, depending mainly upon the incidence of disease (blight and virus) and, to a lesser extent insect pests. Production is grossly insufficient to meet demand and prices are consistently close to import parity.

Mangoes

Senegal produces 0.4 percent of global mango exports, which are destined almost exclusively for European supermarkets. Production is mainly from the Niayes region, although some portion is now being exported from Casamance. Almost all production is rain fed and organic. Fruit is produced by smallholders from individual trees and small orchards and marketed either through associations or directly to end buyers who export by air to Europe. Although Senegal has always produced mangoes for the local market, the export segment has rapidly increased (by 15-fold in five years). In 2005, Senegal experienced a glut of mangoes and prices fell considerably. Improved and expanded marketing arrangements have now reduced the probability of this recurring.

Green Beans

Green beans (also called bobby beans) are primarily grown in Senegal by smallholders and medium-size farmers on contract to wholesale companies who airfreight the produce to Europe. Ninety percent of Senegal's green bean exports are produced in the Niayes region through vertically integrated supply chains. The Senegalese industry is able to fill the out-of-season niche that exists from December through to March before European producers begin production.

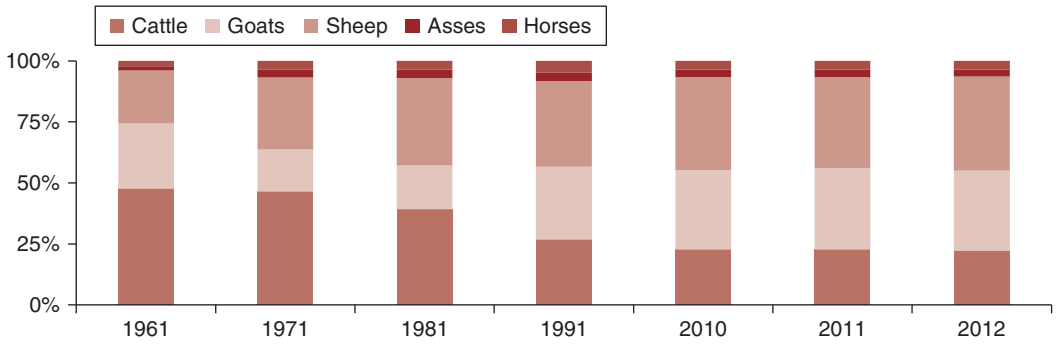
LIVESTOCK PRODUCTION SYSTEMS

Much of Senegal's livestock sector, especially ruminants, remains under a traditional extensive or mixed farming system. Pastoralists produce animal products that are supplemented, in the case of agro-pastoralists, by crops. The annual production is primarily self-consumed but some portion is marketed. Although Senegal's livestock sector is substantial, the country is dependent upon imports to meet its growing demand for meat.

According to FAO data, the main species are cattle, sheep, goats, pigs, poultry, equines, and camels. Livestock are kept largely for meat, and to a lesser extent, for dairy and other products. They are also important for draft power. Small ruminants dominate the livestock sector, as shown in figure 2.5. Sheep are particularly important during the annual religious feasts of Tabaski and at baptisms of newborns. Pigs are of limited significance, being consumed only by the small non-Muslim population. According to FAOSTAT, pork meat represents roughly 6 percent of the total meat consumed [data taken from FAO's online database at faostat.org].

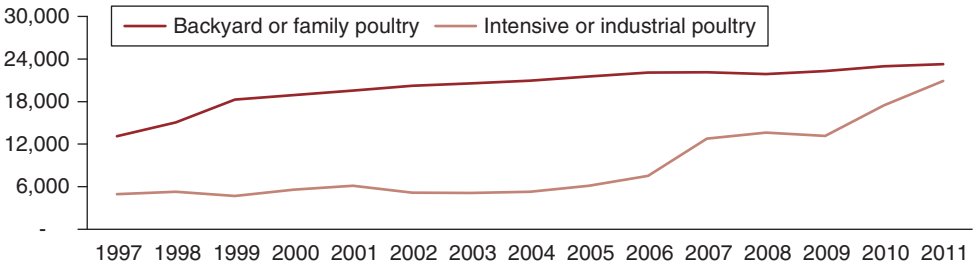
The poultry population in 2012 was 44 million birds. Modern or intensive systems are usually practiced in urban and suburban areas and associated enterprises vary in terms of levels of technical sophistication. These range from highly developed and bio-secure enterprises to backyard, village production. Today, poultry production is split roughly equally between intensive commercial farms and backyard or village production, with growth in the former segment eclipsing noncommercial production (FAO 2014). The intensive sector is dependent upon six

FIGURE 2.5. SHARE OF LIVESTOCK UNITS IN SENEGAL, 1961–2012



Source: FAOSTAT.

FIGURE 2.6. GROWTH IN POULTRY PRODUCTION (thousands), 1997–2011



Source: DAPS (Direction de l'Analyse de la Prévision et des Statistiques).

feed manufacturers and 10 hatcheries producing up to 14 million day-old chicks per year.

Poultry products are important to food consumption, particularly among urban households. Chicken is the third most consumed meat after beef and mutton (FAO 2014). Average per capita consumption of poultry meat per year is 3 kg. According to the Ministry of Livestock (2011), Senegal produces 499 million eggs per year, with average annual per capita consumption of approximately 20–25 eggs. Government policy has focused upon achieving self-sufficiency in poultry production and has put in place measures to reduce competition from imported poultry products as well as to support the production of maize to ensure an adequate supply of poultry feed. Intensive poultry production has increased substantially as a result (figure 2.6).

The significance of the livestock subsector is considerable. Livestock production occupies 30 percent of the population and generates about 36 percent of agricultural GDP and 3.7 percent of total GDP (1994–2000). Sixty-eight percent of Senegalese households, 90 percent of rural households, and 52 percent of urban households have herds. Livestock also provide significant advantages: (1) a very wide and diversified range of products according to agro-ecological zones; (2) draft power for transport or cultivation;[3] and (3) especially for poultry, opportunities for export of animal products made possible by a favorable animal health situation and a supportive trade policy environment. It is also worth noting that market dynamics in Senegal are highly influenced by supply and demand in two neighboring countries: Mali and Mauritania.

AGRICULTURAL MARKETS AND TRADE

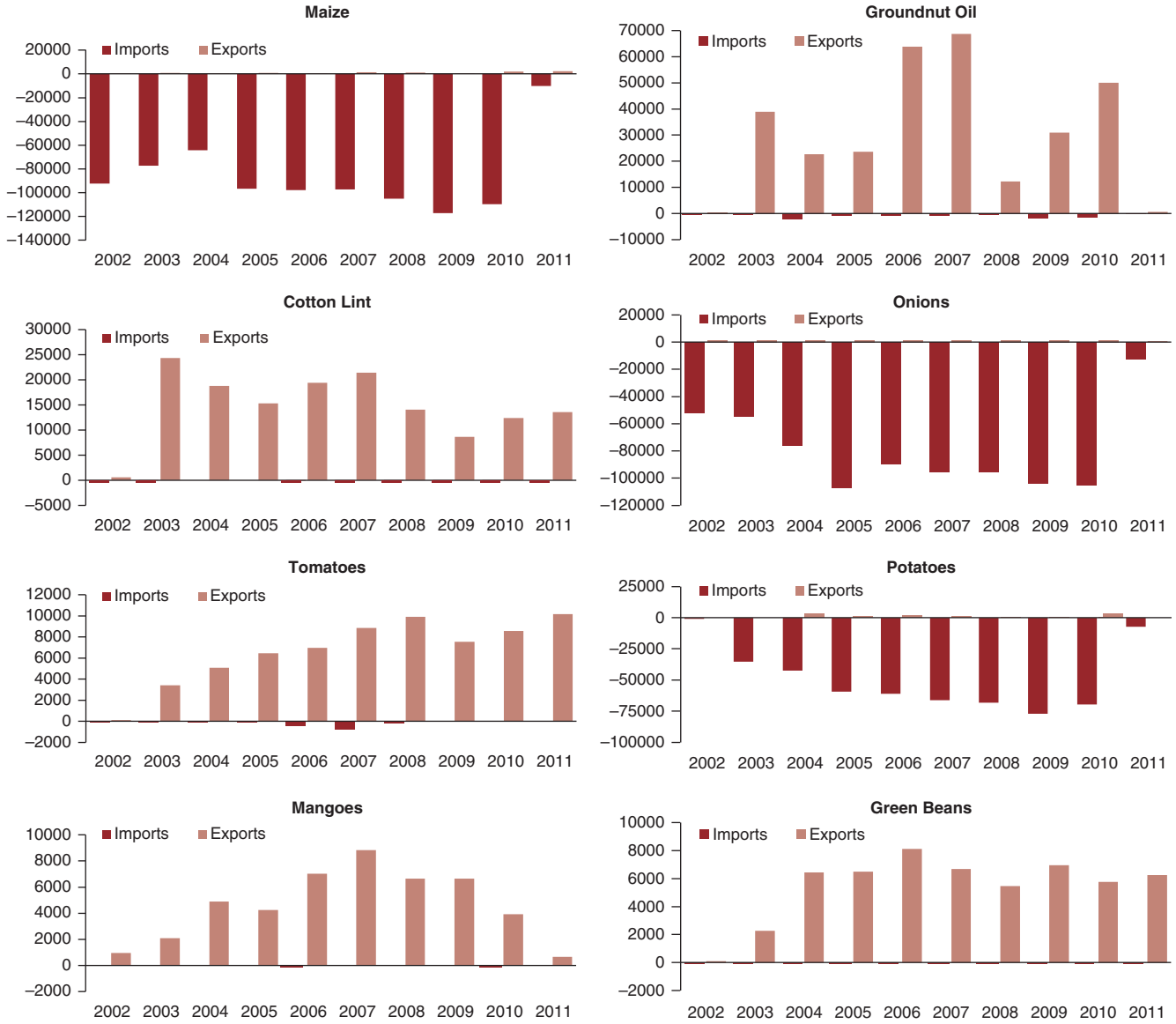
Senegal exports substantial volumes of the high-value products such as groundnut oil and cotton (mainly to China and to Europe) and cherry tomatoes, green beans, and mangoes (also to Europe). It also imports equally substantial volumes of rice, wheat, maize, onions, and potatoes, some which are also produced domestically but in volumes insufficient to meet local demand. Prices for many of these commodities are thus strongly influenced by international market prices.

The export and import volumes of the main cash crops are shown in figure 2.7. There is a marked contrast between the trade in cash crops, for which large volumes are consistently traded in a given direction, and domestic staple crops. For the latter, volumes are generally small and the trade is inconsistent[4] (figure 2.8). Only rice is consistently imported in large volumes of 0.75–1.1 million MT per year. Hence, with the exception of rice, the international market is of little significance to these domestic staples. Year-on-year exports of processed groundnut oil are highly erratic but have exceeded 65,000 MT in the past, whereas exports of cotton lint have declined by roughly half since hitting their peak in 2003.

[3] An estimated 90 percent of rain-fed agricultural land in Senegal is plowed by animals.

[4] FAO trade data for cowpeas are captured under the general heading "dry beans," of which Senegal intermittently exports small volumes.

FIGURE 2.7. TRADE IN CASH CROPS (IN MT), 2002–11



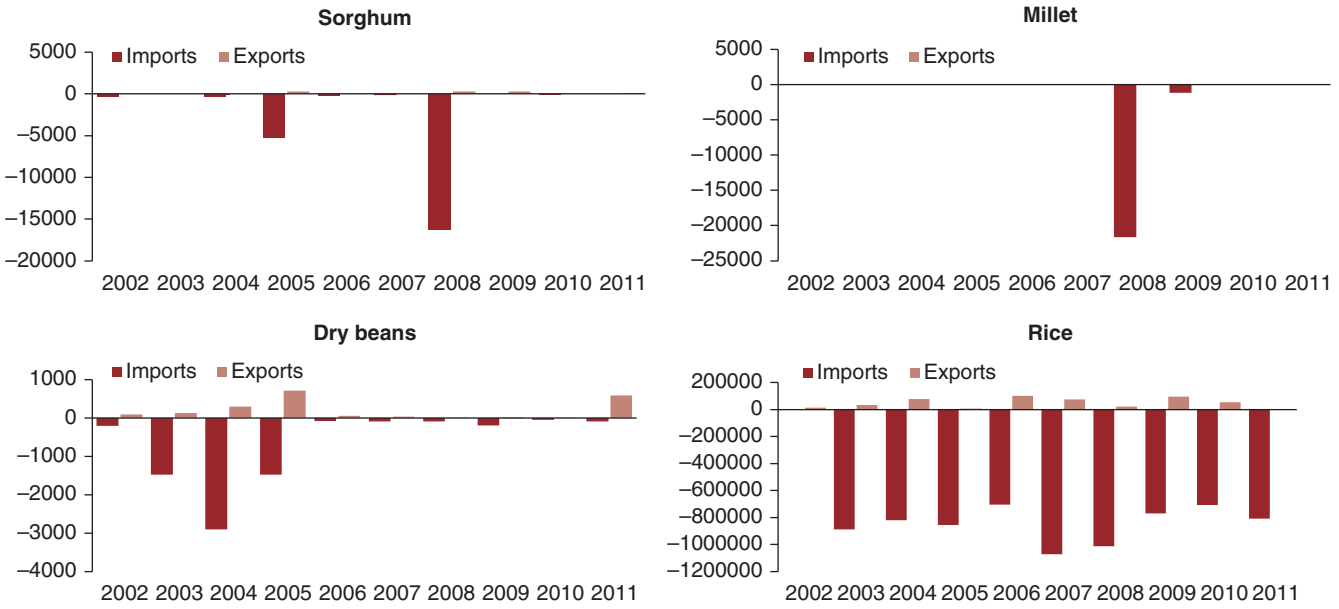
Source: FAOSTAT.

NATIONAL AGRICULTURAL POLICY

Successive programs have all stressed the importance of stimulating productivity, achieving food self-sufficiency, and attracting new investments into the sector. Institutional reforms implemented since 1980 have generally facilitated the withdrawal of the state from agricultural production and marketing, the restructuring and reorientation of public enterprises, and support favoring increased private and cooperative sector participation. Adopted in 2004, the Loi d'Orientation agro-sylvo-pastorale (LOASP) provides the overall, long-term policy framework for public sector administration and investments in the agriculture, forestry, and pastoral sectors. However, implementation of the law since adoption has generally been slow.

Building on Senegal's Poverty Reduction Strategy Papers I (2003–05) and II (2006–10), the current Stratégie de Croissance Accélérée (SCA) adopted in January 2008 targets an economic growth rate of 7 to 8 percent via the expansion of five key sectors including agriculture and agro-industries. The Programme d'Accélération de la Cadence de l'Agriculture au Sénégal (PRACAs) provides the organizational and operational framework for GOS interventions in promoting sustainable agriculture, productivity, and farm-

FIGURE 2.8. TRADE IN STAPLE CROPS (IN MT), 2002–11



Source: FAOSTAT.

ers' resilience to external shocks. PRACAS is an integral part of the Plan Sénégal Emergent (PSE), which defines the country's overall development goals. It places the agriculture sector at the heart of economic development. It highlights climate change as a major challenge and stresses the importance of finding effective and sustainable solutions to enable people to adapt and build their resilience against climate shocks and other hazards.

All key elements of support to both crop and livestock sectors are present in Senegal, including research into plant breeding and disease control, multiplication and dissemination of government-bred seed stocks, veterinary services and livestock disease control programs, agricultural extension, provision of subsidized inputs (fertilizer and seed), and input loans. GOS has also supported programs promoting improved access to crop and livestock insurance, although coverage is limited and the level of service provided remains low.

Research in particular to produce disease-resistant and short-season crop varieties (for example, groundnut, maize, cowpea) is ongoing and substantial progress has been made in recent years in making these available to farmers. However, the majority of farmers continue to face difficulties in sourcing improved varieties and home-grown, recycled seeds are still widely used. In terms of direct risk mitigation efforts, the government participates in regional locust control activities and undertakes national livestock vaccination and emergency feed distribution campaigns, although the scope and reach of these programs can be variable.

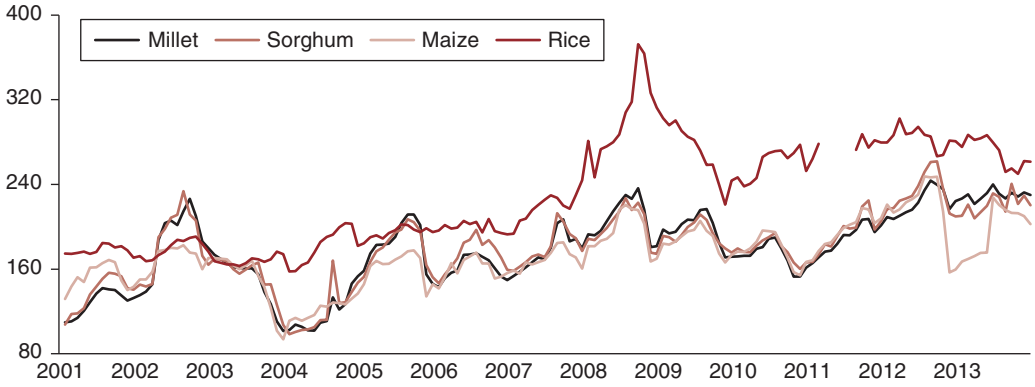
Despite signs of progress, the current situation leaves farmers, herders, and other sector stakeholders vulnerable to a wide range of natural hazards and other shocks. It also in part explains why the sector has fallen short of achieving sustained growth despite high rates of public investment in the sector.[5] A more targeted and systematic approach to risk management is needed to protect livelihoods and support sector growth and development.

FOOD SECURITY

At the national level, food security in Senegal, as measured by the Bonilla Index (Diaz-Bonilla et al. 2000) is among the lowest in Africa, ranging from 0.48 to 0.72 during the period 1995–2010.[6] The 2013 national food security and nutrition

[5] In 2013, public expenditures in the agricultural sector reached 9.2% of Senegal's national budget, just shy of the 10% commitment under the Framework of the Comprehensive Africa Agriculture Development Programme (CAADP).
[6] The Bonilla Index is the ratio of the value of food imports to the value of total exports. As an index, it captures both domestic productivity and the cost of imported foodstuffs, that is, both the availability of and access to food.

FIGURE 2.9. RETAIL PRICES FOR KEY STAPLE CROPS (CFA/KG), 2001–13



Source: DAPS.

survey found that 18.8 percent of households, corresponding to some 245,000 households or 2.2 million people, are food insecure. The situation is especially accentuated in rural areas, where 25.1 percent of households are food insecure versus 15.1 percent reported in 2010. In recent years, food insecurity has dramatically worsened in the conflict-affected Casamance (Kolda, Sedhiou, and Ziguinchor regions), as well as in the Kedougou and Matam regions (WFP 2013) (see Senegal Comprehensive Food Security and Vulnerability Assessment 2013, SE/CNSA, SAP, WFP). National levels of stunting at age 5 are 26.5 percent (this statistic comes from the UNICEF database at http://www.unicef.org/infobycountry/senegal_statistics.html).

Although demand exceeds local supply, imported foodstuffs are available in markets throughout the country and it is only in the most isolated areas that food insecurity could be described as an issue of food availability. Household economic analysis has shown that the majority of the rural poor are dependent upon markets to meet their food needs. Markets for staple crops are not strongly developed, though they are both extensive and reasonably well integrated. Nevertheless, there is a high degree of uncertainty in terms of domestic cereal prices which can fluctuate substantially both within and between seasons.

Figure 2.9 highlights the high degree of uncertainty that many households face as domestic cereal prices fluctuate substantially both within and between seasons. It is this fluctuation in domestic market prices (together with global price variations) that is the fundamental cause of food insecurity in Senegal. Local production levels are always inadequate to meet demand. Thus, it is the price of food and a household's capacity to pay that price that largely determines food security in Senegal.

KEY GROWTH CONSTRAINTS AND TRENDS

In Senegal, low levels of soil fertility and limited farmer use of improved seeds, fertilizers, and agro-chemicals (for example, insecticides) limit productivity. In the absence of mechanized equipment and services, there is a high reliance on family labor. Poor access to inputs and financial services further contributes to low adoption of productivity-enhancing technologies. Inadequate storage, roads, and other marketing infrastructure discourage farmers from investing in upgrades. For the livestock subsector, low-performing breeds, poor husbandry management, insufficient feed/fodder supply, high cost of poultry feed, and strong competition from imports are among key growth constraints. These constraints hinder sector growth by limiting many producers' ability to raise productivity and move beyond subsistence. These same constraints can also amplify the impacts of adverse shocks by increasing the scope of losses and weakening the coping capacity of agricultural stakeholders.

In addition to constraints, trends such as climate change, soil erosion, and decreasing groundwater availability as a result of salinization and declining water tables are increasing the vulnerability of producers to climate risks and other threats.

CHAPTER THREE
AGRICULTURE SECTOR RISKS

The main sources of risk in Senegal's agricultural sector are reviewed in this chapter. These include production risks, market risks, and a general set of risks associated with the enabling environment for agriculture. The incidence and implications of multiple or successive shocks are also considered.

PRODUCTION RISKS

In terms of production, the most important factor contributing to agricultural risk is weather. Other factors include crop pests and diseases (both before and after harvest), windstorms, bush fires, and livestock diseases having weak response mechanisms. Each of these factors is considered in more detail below.

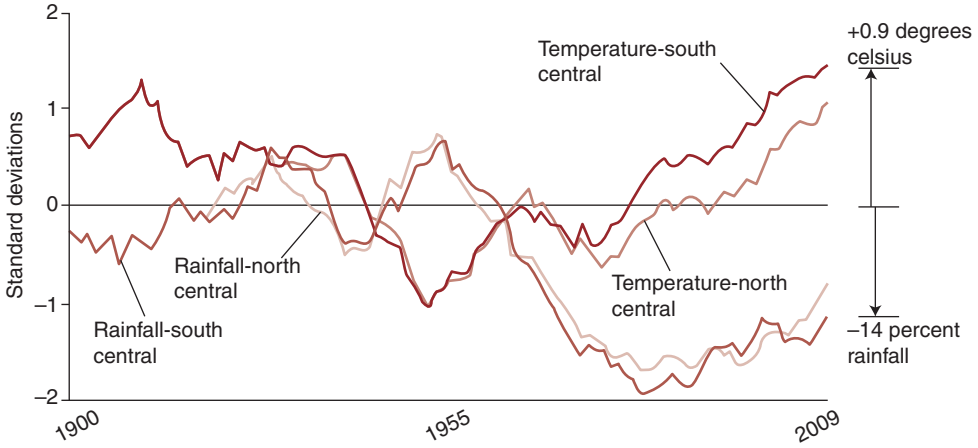
WEATHER RISKS

Weather-related risks manifest mainly through extremes of temperature and precipitation. In the former case, the actual impact of extreme temperatures upon crop yields in Senegal is uncertain. Over the past 40 years, mean annual temperatures across Senegal have increased rapidly (averaging 0.19°C per decade), but prior to that period, mean annual temperatures had decreased substantially, so that current mean annual temperatures have only recently regained the levels experienced at the beginning of the last century (figure 3.1).

Extreme Temperatures

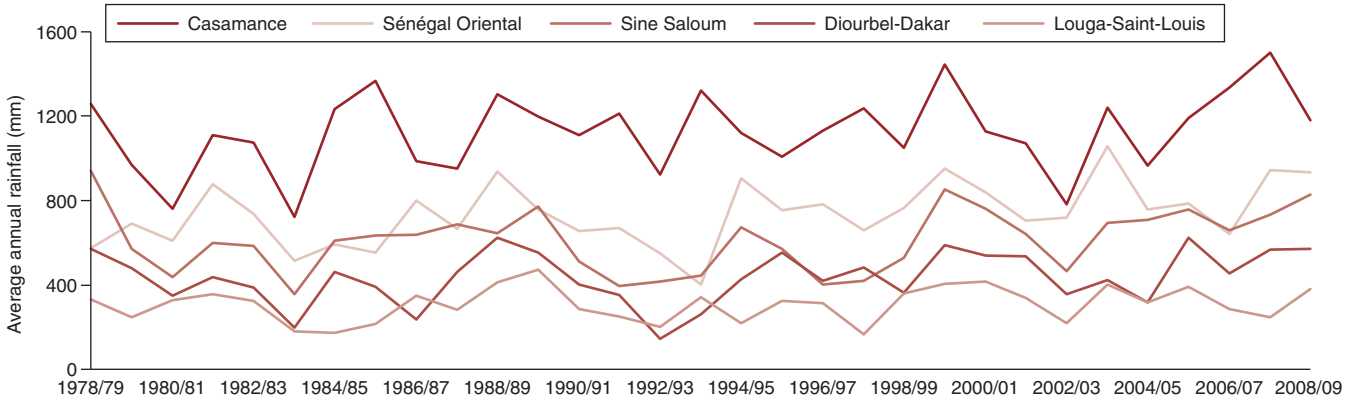
Although it is evident that high temperatures that inhibit plant production (generally in excess of 35°C) will occasionally occur during the growing season, their impact is not easily determined, because it will often have been confounded by moisture stress. Similarly, the impact of extreme cold is not easily measured because it occurs so rarely in Senegal (although an important exception is the impact of cold rain upon weakened livestock, as happened in 2002). Extreme temperatures may well constrain production, but although changes in the frequency and impact of extreme temperature anomalies can be modeled (see appendix A), they are not empirically evident. Temperature per se is rarely considered by stakeholders as a contributory factor to crop production risk, and does not feature as an observed cause of ex post impacts.

FIGURE 3.1. VARIATIONS IN TEMPERATURE AND RAINFALL, 1900–2009



Source: Funk et al. 2012.

FIGURE 3.2. PRECIPITATION PATTERNS OF MAJOR REGIONS, 1978/79–2008/09



Source: ANACIM.

TABLE 3.1. VARIABILITY OF RAINFALL BY REGION

	Casamance	Sénégal Oriental	Sine Saloum	Diourbel-Dakar	Louga-Saint-Louis
Mean	1125	735	611	437	308
Standard deviation	189	149	149	123	80
Coefficient of variation	17%	20%	24%	28%	26%

Source: ANACIM.

Erratic Rainfall

The single most important factor affecting crop production is the availability of moisture. Moisture stress can manifest itself through the delayed onset of rains, through erratic rain, through the early cessation of rain, or through extended drought, all of which can result in reduced yield. Nevertheless, even in the absence of these specific conditions it has been shown that more than 40 percent of the variation in national crop yields can be ascribed simply to the variation in annual rainfall amounts. (Kandji, Verchot, and Mackensen 2005). Annual rainfall tends to decrease with latitude, being highest in the south of the country and decreasing to the north (figure 3.2).

In general, the variability of rainfall tends to increase as the absolute amount decreases (table 3.1), although the

high variability of rainfall in Louga-Saint-Louis appears to be an exception to this pattern. More detailed rainfall analysis supports the general thesis that not only do yields decrease moving from south to north, but the probability of an abnormally low yield due simply to reduced rainfall is also increased.

The various detrimental aspects of rainfall tend to act in specific ways. The impact of erratic rainfall is modified to a considerable extent by the growth stage of the crop under consideration. Thus, maize may experience erratic rainfall during early growth yet still yield well, whereas the impact of the same rainfall regime during tasseling and silting, when evapotranspiration demand is much higher, can result in substantial loss of yield. Similarly, sorghum and millet are prone to notable yield reduction if rainfall amounts are reduced during inflorescence. By contrast, cotton has an indeterminate growth form that allows it to recover from a period of moisture deficit, although germination and early seedling growth can be much reduced by moisture stress (FAO 1971). Cowpeas and groundnuts are particularly affected by dry conditions during pod development.

Drought

The early cessation of rain can cause loss of yield through reduced grain filling, especially in groundnuts and, to a lesser extent, maize and cowpeas. Its impact is less pronounced for sorghum or millet, or an indeterminate crop such as cotton but can have a major effect on horticultural crops such as potatoes or tomatoes. Detrimental impacts can be reduced through the planting of short-season varieties, although these may be lower yielding than their longer-season counterparts.

The risks to production posed by erratic rainfall or drought are particularly significant because they occur once the farmer has invested the bulk of the required resources into the crop and there is effectively "no going back." By contrast, the risk of the delayed onset of rains, which can result in poor germination and death of young seedlings, can be avoided by late planting. If planting is delayed beyond a certain extent, then yields will invariably suffer. However, it may be possible to delay planting and benefit from abnormally late rains to achieve normal yield levels. This response to the possibility of delayed onset of rains is widespread across Senegal.

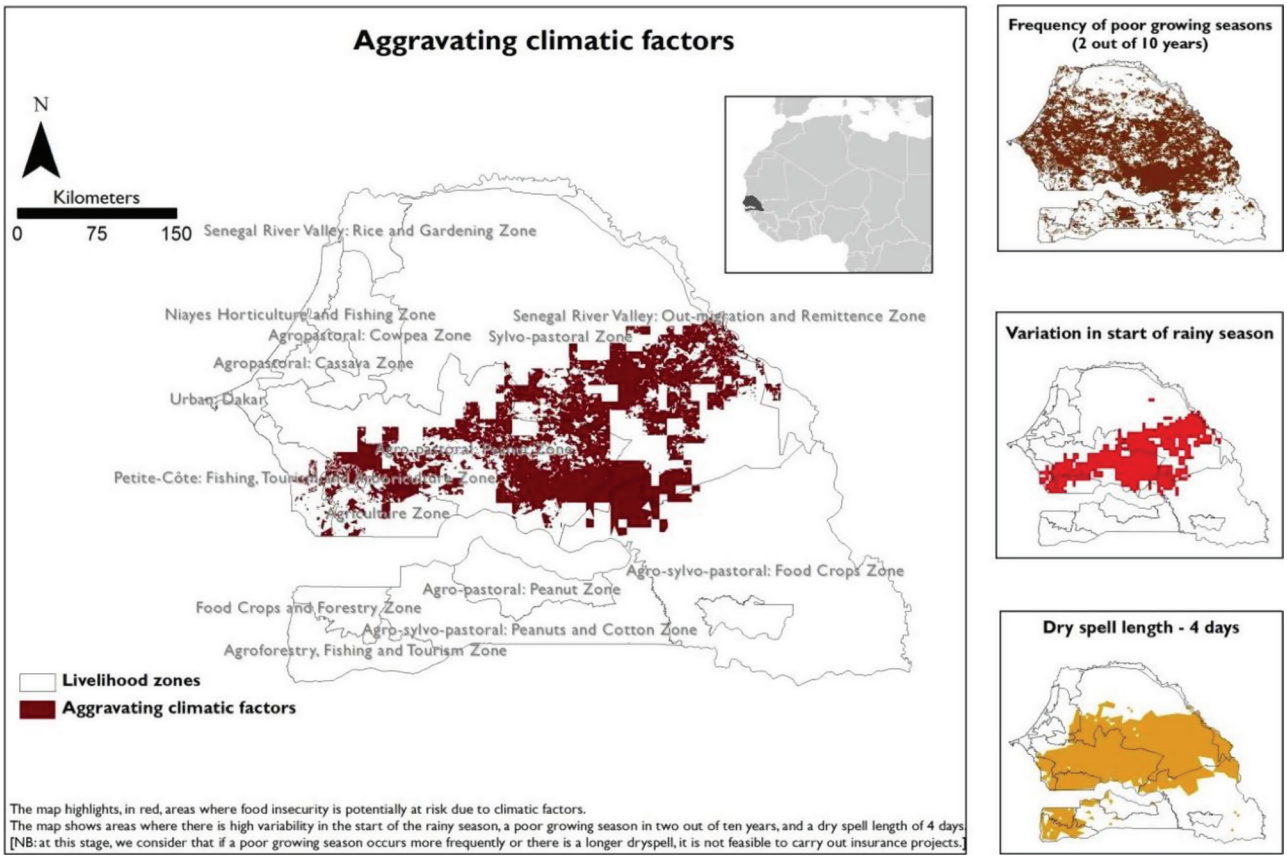
Today, the majority of growers do not plant at the statistically optimal period, but wait until they are convinced that the rains have set in properly. This has the result of limiting potential production, because limited mechanization capacity causes the period of soil preparation and sowing to be extended well past the optimal sowing date. Indeed, in the case of millet, research showed that there was little to no impact of delayed rains upon yield. This occurred because growers generally waited for a traditional date before sowing, a date at which the rains would have almost certainly set in. This date may not have been optimal for production, but had become accepted as part of an effective risk mitigation strategy.

When the probabilities of late onset and early cessation of rains are mapped, it is evident that the highest probability of both occurs in the middle latitudes of Senegal (figure 3.3). This area is very similar to that where the probability of erratic rainfall is also highest. Consequently, even though the area may not experience the lowest levels of rainfall, it is the area in which the contribution of uncertain precipitation to risk is the highest. It is notable that this area includes the Groundnut Basin as well as part of the maize and cotton production areas. The production of these crops is thus particularly exposed to risk due to uncertain rainfall.

An analysis of standardized cumulative rainfall data collected from 25 weather stations over the period 1980–2013 is summarized in table 3.2. The analysis provides insights into the frequency and severity of rainfall events during the 34-year period. For the purpose of this analysis, drought is defined as rainfall less than one standard deviation (>−1) from the mean and extreme drought as rainfall less than two standard deviations (>−2) from the mean, whereas excess rainfall and severe flooding are defined as rainfall more than one (>1) and more than two (>2) standard deviations from the mean, respectively.

During the review period, the country experienced 10 years of drought, three of which were categorized as severe drought (1980, 1983, 2002). This equates to a frequency of drought of roughly one out of every three to four years, on average. A subsequent analysis of crop yield losses showed that these severe drought years coincided with the largest losses in terms of annual crop production value. The probability of drought was highest in

FIGURE 3.3. CLIMATE VARIABILITY MAP FOR SENEGAL



Source: ANACIM, WFP, IRI 2013.

Tambacounda and Kolda. Regional droughts affected production in on or more province during other years (for example, 1986, 2003), but these events were not classified as drought due to their localized nature. It is worth noting that the analysis of cumulative rainfall fails to capture the poor rainfall events in 2007 and 2011 that severely affected crop and livestock production during those years. A more detailed table summarizing the analysis can be found in appendix G.

Floods

The rainfall analysis also highlights an observed *wetting* trend, with a higher frequency of excess rainfall years in the most recent decade. It is worth noting that since the droughts of 1996–97, there has been only one episode of drought (2002), an extreme event that affected half of Senegal's 14 provinces. According to the analysis, Senegal has experienced nine excess rainfall years since 1980; all but one (1989) of these events occurred during the past 15 years. During the most recent decade, Senegal experienced excess rainfall more than half the time, or six out of 10 years (see appendix G, table G.2). In 2010, abnormally high rainfall was recorded in as many as 13 of Senegal's 14 provinces, when floods devastated many parts of the country.

It is worth noting that despite the observed increasing frequency of flood events in Senegal, the analysis suggests that associated impacts relative to losses to crops and rural livelihoods are limited. Although individual farms may be prone to flooding (especially some of the lowland rice areas), the majority of agricultural production is not at risk from flooding and few respondents reported this as a risk to crops. Notwithstanding, impacts to urban households and infrastructure can be substantial. To illustrate, flooding in 2009 in Dakar cost over US$100 million and affected over 400,000 people (GFDRR 2012). Although direct losses to crops and livestock from flooding may be limited at the aggregate level, extreme rainfall events do contribute to leaching and soil erosion, when organic matter and other soluble plant nutrients in the topsoil are carried away. This impedes the future capacity of soils to retain nutrients and moisture. Researchers have identified

TABLE 3.2. FREQUENCY AND IMPACT OF RAINFALL EVENTS BY REGION, 1980–2013

Year	Event	Provinces Affected	Inidicative Loss Value: In US$	Inidicative Loss Value: % of Agr Production Value*
1980	xx	Matam, Diourbel, Fatick, Kaolack, Tambacounda, Kolda, Sedhiou, Ziguinchor	−128.2	−19
1983	xx	12 of 14 provinces (exluding St. Louis and Matam)	−128.5	−9.3
1984	x	Saint-Louis, Matam, Dakar, Tambacounda	−91.7	−13.8
1989	+	Louga, Dakar, Thies, Diourbel, Zuiquinchor	–	–
1990	x	Saint-Louis, Fatick, Kaolack, Kaffrine, Kedougu, Kolda	–	–
1991	x	Matam, Kaolack, Kaffrine, Tambacounda, Kolda, Sedhiou	−9.6	−1.4
1992	x	Saint-Louis, Louga, Matam, Dakar, Kedougou, Ziguinchor	−69.8	−10.5
1996	x	Saint-Louis, Diourbel, Kaolack, Kolda	−50.3	−7.5
1997	x	Louga, Matam, Fatick, Kaffrine	−68.0	−0.2
1999	++	Matam, Kaolack, Kaffrine, Tambacounda, Koudougou, Kolda, Ziguinchor	−33.5	−5.0
2000	+	Matam, Thies, Fatick, Kaolack, Kedougou	−28.1	−4.2
2002	x	Saint-Louis, Louga, Thies, Tambacounda, Kolda, Sedhiou, Ziguinchor	−217.3	−32.6
2003	+	Saint-Louis, Matam, Tambacounda, Kedougou, Kolda, Sedhiou	−15.3	−2.3
2005	+	Dakar Diourbel, Kaffrine, Kolda	–	–
2008	+	Thies, Diourbel, Fatick, Tambacounda, Ziguinchor	−9.5	−1.4
2009	++	Saint-Louis, Louga, Dakar, Diourbel, Fatick, Thies, Tambacounda	−10.7	−1.6
2010	++	13 of 14 provinces (except Diourbel)	−19.1	−2.9
2012	++	11 of 14 provinces (except Louga, Kedougou, Kolda)	—	—

Key: x Drought; xx Severe drought; + Excess rainfall; ++ Severe flooding

Source: ANACIM 2014; FAOSTAT; Authors' calculations and notes.
*Average 2005–07

resulting low rates of fertilizer-use efficiency as a key reason why more farmers choose not to invest in fertilizer.

Hail and Windstorms

Other weather-related risks to agriculture in Senegal include hail and windstorms. Hail is a common component of Intertropical Convergence Zone (ITCZ) precipitation and there is a high probability that in a given year some crops will be damaged by hail. Nevertheless, although the impact of a hailstorm can be devastating at an individual smallholder level (resulting in 100 percent loss of crop under the worst circumstances), the geographic extent of such impact is so limited that hail has no discernible impact on yield from a national perspective.

The impact of windstorms appears to be similar to that of hail, albeit to a lesser extent, perhaps with once critical distinction. Sustained windstorms contribute to soil erosion, particularly in flat areas with dry, sandy, and/or finely granulated soils, which can be found in key production zones across Senegal. Resulting wind erosion damages land and natural vegetation by removing soil from one place and depositing it in another. It contributes to the deterioration of soil structure and causes nutrient and productivity losses.

BUSHFIRES

The risk to production posed by bushfires can be significant at an individual smallholder level toward the end of crop production when crops are mature and combustible, but at the aggregate level the impact of bushfires on national crop production is negligible. By contrast, bushfires can have a significant impact on livestock production, both positive and negative. Early burning can result in regrowth from soil moisture reserves, which can help to extend the grazing season. Late burning tends to result in fiercer fires that damage the bush upon which cattle and goats graze in the dry season. Estimates suggest that as much as 6 percent of the potential dry season grazing area suffers from bushfire each year (Oceanium 2014). Data shared by the Centre de Suivi Ecologique (CSE) suggest that on average 3.8 million MT of biomass are lost annually through bushfires. This is equivalent to 100,000 MT of meat and can have a major impact upon production levels in those areas in which such burning has occurred. According to CSE, 762,921 hectares of land were ravaged by bushfires during the period October 2012 through May 2013, representing roughly 3.9 percent of national territory (CSE 2013). The vast majority of this occurred in the southern half of the country. The region of Tambacounda was the most affected, accounting for a third of the national total. Large swaths of pastureland in Sédhiou and Kédougou were also damaged by bushfires, accounting for 11 percent and 10.16 percent, respectively, of total land.

CLIMATE CHANGE

The impact of historical and future climate change on rainfall amounts and intensities in Senegal is uncertain. Historically, national rainfall data suggest that cumulative rainfall amounts were decreasing until 1990, but since then annual levels show an increasing trend. It is possible that this is due more to decadal and/or multidecadal climatic cycles than to a longer-term trend (Kandji, Verchot, and Mackensen 2005). It is worth noting that anecdotal evidence collected for this study has indicated that the frequency and intensity of dry spells has increased over the past 10–15 years. However, these results are based upon personal recollection, which has been shown to be biased toward a more favorable past (de Nicola and Gine 2011) and should consequently be treated with caution.

Overall, although aspects of climate contribute substantially to the risk faced by producers, the anticipated impact of climate change upon that risk appears to be uncertain, the most consistently predicted trend being an increase in the variability of rainfall amounts (see appendix B). This may be expected to increase the level of risk faced by farmers, but parallel trends in farmers' perception of that element of risk, or in the frequency of weather-related risk events that have affected yield, have not yet been recorded.

CROP PESTS AND DISEASES

Crops in Senegal are subject to depredation by a range of pests. By far the most significant are the Senegalese grasshopper, or "sauteuriaux" (*Oedaleus senegalensis*), locusts (*Locusta migratoria*), and birds. The first two are non–crop specific whereas the third is confined mainly to sorghum and millet (although maize can also be affected).

Most farmers do not have the knowledge and much less the financial means to adequately tackle crop pests; however, all of the stakeholders confirmed that pests and diseases are one of the main risks to agricultural production. There are different ways of dealing with pests and diseases in cash and food crops; although in cash crops inputs are mostly distributed on a credit basis, for food crops fertilizers and pesticides are procured on a cash-and-carry basis or diverted from cash to food crops. There is vast number of pests that damage food crops in Senegal. A more detailed listing of pre- and postharvest pests that damage crops can be found in appendix F.

Since 1980, there have been six major locust invasions in Senegal, with significant impacts on both cash and food crops and livestock. For the period of analysis, the two worst infestations occurred in 1987–88 and 2004–05. Locusts eat crops and other vegetation that is in their area of infestation, often leading to total crop losses. They can also adversely affect livestock production through loss of grazing. Damage is highly localized, but big swarms can cumulatively affect vast tracts of land. During the 1997–98 outbreak, GOS estimates at the time reported that locusts had infested almost 5 million acres of land and destroyed 10 percent of the year's harvest.[7] More than 2 million acres were treated with pesticides to combat the invasion. Control of the locusts and grasshoppers is

[7] See "Senegal Fights Worst Locust Infestation in 30 Years" by Susan Katz Miller, 25 November 1988.

usually through chemical pesticides, which can harm a wide range of organisms. Since 2000, a more ecological solution has been available with the entomopathogenic fungus *Metarhizium anisopliae* var. *acridum*, registered as Green Muscle.

In addition to crop and livestock losses, response measures can also be costly. To control 2004's invasion, GOS had initially budgeted for 1.8 billion CFA francs. The state finally had to approve 4 billion CFA francs to bring the menace under control. This does not include outlays in cash and in kind by private citizens, nor bilateral and multilateral inputs. Damages due to locusts for the same outbreak were estimated at 2 million tons of crops, equivalent to 20 percent of the population's food needs in the Sahel region.

Granivorous birds, mainly the red-billed quelea, have subsisted on cereal crops in Africa for centuries and regularly cause substantial damage to crops. A study in Senegal's River Valley estimated that annual bird damage averaged approximately 13.2 percent of the potential rice production during the wet seasons of 2003–07. This translates into an average annual economic loss of 4.7 billion CFA francs (US$9.7 million). These results were consistent with farmers' perceived bird-inflicted crop losses, averaging 15.2 percent.

There are more than a dozen fruit fly species that attack mangoes. Across West Africa, losses from damage caused by mango fruit flies (*Tephritidae diptera*) have been growing. This is especially true since the arrival of *Bactrocera invadens*, a fly species from Sri Lanka, first discovered in West Africa in 2004 by the International Institute of Tropical Agriculture (IITA) in Benin. The insect pest has the potential to jeopardize the recent commercial success of the region's mango export sector. Fruits showing the slightest trace of a fly bite must be identified, removed, and destroyed during harvesting and in-station sorting. Because fruit flies are classified as "quarantine insects," if a single fruit is detected that is infested with larvae, the whole batch can be rejected by European phytosanitary services. According to the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CPA), whole containers of fruit from Africa are regularly intercepted and destroyed each year in incinerators in European harbors and airports because of infestation. This results in substantial economic losses for exporters. More important, due to reputational risks, the confiscation of a single batch can ruin the efforts of a whole campaign.

LIVESTOCK DISEASES

There is a wide range of diseases that threaten and adversely affect livestock production in Senegal. However, many diseases can be considered as constraints rather than risks, as they rarely lead directly to animal mortality and the majority of owners know how to manage them. However, growing animal populations, declining vaccination coverage, and erratic availability of quality vaccinations and medicines are among factors that can weaken existing risk management capacity. This report concentrates on diseases that are either of a trans-boundary nature or of major zoonotic concern, and considers them in terms of the risk to local and international trade or potential risk to the human population.

The World Organization for Animal Health (OIE) conducted an in-depth review in 2010 of livestock diseases in Senegal. Table 3.3 provides a list of the most important diseases threatening cattle, small ruminants, and poultry. During the present mission, interviews with senior government and private vets revealed that many of the constraints and recommendations made in the OIE report still reflect the situation today.

Although some diseases constitute a risk themselves, the major risk to the livestock sector remains the inability of the veterinary services to respond to needs. Whereas disease control policies and strategies exist on paper, it is widely recognized that because of chronic underresourcing and resulting scarcities of material resources and qualified personnel, the ministry is often unable to implement them or respond as required. Recognizing this challenge, the veterinary department has recently reprioritized and now covers fewer diseases in their vaccination campaigns, concentrating on PPR, Newcastle disease, African horse sickness (AHS) and lumpy skin disease, with episodic campaigns against other diseases as they occur (for example, CBPP, pox). Of particular note: the OIE report emphasizes the involvement of the communities in policy design and implementation; a recommendation that this study strongly supports.

TABLE 3.3. MAJOR LIVESTOCK DISEASES

Species	Diseases Vaccinated Against	Diseases under Surveillance
Cattle	Lumpy skin disease (LSD/DNCB) Foot and mouth disease Hemorrhagic septicemia/ Pasteurellosis (HS) Blackleg Anthrax Botulism	Rinderpest (RP); Contagious bovine pleuropneumonia Rift Valley fever
Small ruminants	Peste des petits ruminants (PPR) Pasteurellosis	Rift Valley fever
Poultry	Newcastle disease (NCD)	Highly pathogenic avian influenza (HPAI)

Source: Gary et al. 2010.

BOX 3.1. CASE STUDY: CONTAGIOUS BOVINE PLEUROPNEUMONIA (CBPP/PPCB) IN SENEGAL

CBPP (PPCB) was eradicated in Senegal in 1978 and vaccinations ended in 2005. But in November 2012, there was an outbreak in the south after animals crossed into the country. Additional outbreaks have been reported in 2013.

Impact:

- Losses in production, including some mortality.
- Restrictions on movement.
- Higher veterinary (and vaccination) costs.
- Need for up to a further 10 years of vaccination and surveillance.

Among livestock diseases, this assessment considers Rift Valley fever, highly pathogenic avian influenza, and Newcastle disease to be among priority livestock production risks. Avian influenza and Rift Valley fever can also have a significant impact and influence on both local and international trade. As notifiable diseases, they can also affect policy decisions, which have the potential to cause damage to livestock systems if they are inappropriate or are implemented quixotically.

Paradoxically, other diseases such as foot and mouth disease and contagious bovine pleuropneumonia, could potentially cause even greater harm if the response mechanisms required for control and eradication were actually put in place. Such measures would necessitate the slaughter of whole herds, which would have a major impact on the whole livestock industry not to mention the livelihoods of hundreds of thousands of households who depend on it. However, in Senegal, export of locally produced animal products (with the exception of day-old chicks and eggs) is virtually nonexistent, and most animals are of the local indigenous breeds and quite tolerant of the above diseases. The government implements less extreme control measures and although there are some losses in productivity, the impact is relatively insignificant.

Other diseases that occur in Senegal are largely known and to some extent predictable. Thus, these are considered more as production constraints (for example, trypanosomiasis,, helminthiasis). Most well-maintained animals recover naturally from disease even if left untreated; however, productivity is obviously affected and most owners will opt to treat the diseases. The risk is that without proper prevention, when a large outbreak occurs, the losses can be considerable, as very few animals have been vaccinated. According to officials at the Ministry of Livestock and Animal Production, approximately 5 percent of poultry is vaccinated against Newcastle disease each year; 20 percent of smallstock; 63 percent of cattle; and 38 percent of horses. In addition, the quality and efficacy of available vaccines is questionable; it is estimated that as many as 50 percent of veterinary products used could be counterfeit or of poor quality. Thus, it is the lack of adequate vaccination services and mostly the new, emerging diseases that this study highlights as the major risks.

MARKET RISKS

Among the most common market risks presented in this section are price variability for crops and livestock, exchange rate and interest rate volatility, and counterparty risk.

CROP PRICE VOLATILITY

Price fluctuations are to be expected in agricultural markets. This is partly due the unpredictable nature of supply and demand, weather patterns, and related yields. However, extreme price volatility deters producers from making productivity-enhancing investments and can jeopardize household access to food among poorer segments of the population.

The impacts of the global price increases in food and fuel experienced in 2007-2009 were substantial. The 30 percent increase in the price of household foodstuffs (for example, rice, cooking oil, sugar, wheat, millet, milk products) increased poverty levels by six percentage points, from 51 percent in 2005/06 to 57 percent in 2008 (Del Ninno and Mills 2015). In 2007 and 2008, the price of rice in local markets tripled, whereas grain prices increased by 50 percent. People took to the streets to protest these price increases, with riots destabilizing the political environment. Domestic food prices were 74 percent higher at the end of 2012 than they were in early 2006, according to FAO's food price index. As a result, living conditions of the poorest households continue to deteriorate, with reductions in the quality and frequency of meals and higher incidences of food insecurity and malnutrition.

Although the risks associated with price can be important for household well-being, they are of only marginal significance to crop producers. This is especially true of staple crops such as millet, sorghum, and cowpeas. Although high prices of these commodities can have a drastic impact on food security, they do not have a major impact on the finances of producers, most of whom will consume almost all that they produce. This is less true of maize and rice, which are produced more as cash crops that must compete with imported commodities so that low international prices can result in reduced profitability. The same is true for export fruit and vegetables, including mangoes, tomatoes, and beans, all of which must compete on world markets so that producers are directly affected by international prices and by exchange rate fluctuations.

TABLE 3.4. INTER-ANNUAL CROP PRICE VARIABILITY, 1991–2011

Coefficients of Variation			
Cereal Crops		**Cash Crops**	
Maize	0.29	Cotton*	0.15
Sorghum	0.31	Groundnuts	0.21
Millet	0.34		
Rice (paddy)	0.34		

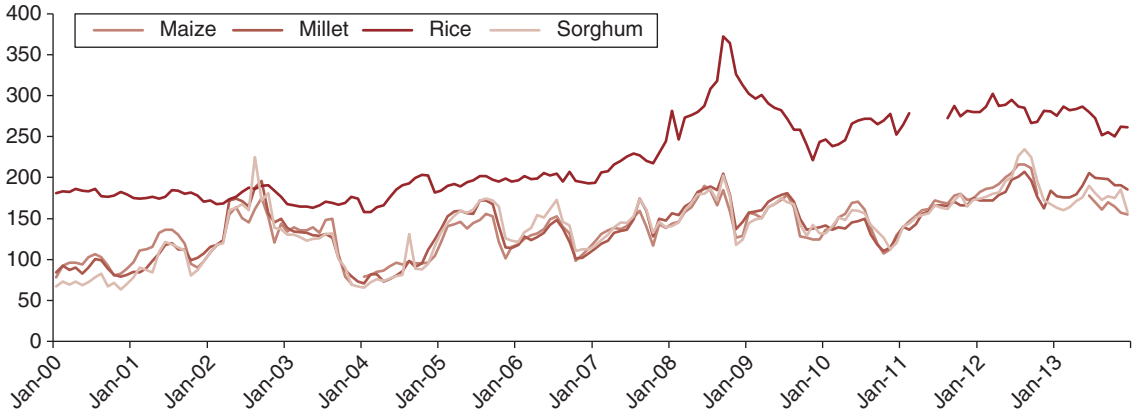
Source: FAOSTAT.
*Price for cotton lint.

An analysis of producer price variability is based on inter-annual price variability for the period 1991–2011, measured by coefficients of variation (CV). Nominal prices in US$/ton taken from FAOSTAT are used for the analysis of domestic producer prices. Table 3.4 compares levels of inter-annual price volatility across Senegal's principal cereal and cash crops. During consultations in the field, stakeholders repeatedly emphasized the volatility of domestic food crop prices. Indeed, the analysis highlights the extent to which price variation among domestic food crops is considerably greater than that of domestic cash crop prices.

Food Crops

Staple crops are grown throughout Senegal, but the level of production achieved by the majority of households is inadequate to provide 100 percent food security. Thus, most households are dependent upon purchased food for at least some months of each year. The dependence upon markets is greatest in August when prices tend to be highest. The price of staple crops at this time is therefore critical to household food security and the risk that increased food prices might reduce the accessibility of food has a substantial impact upon household resource management. It is difficult to quantify the impacts of risks because of price volatility, but respondents frequently reported the diversion of crop inputs intended for cash crops such as groundnuts or cotton to crops such as sorghum and millet to maximize food availability. They also cited retention of grain at the household level, this despite inadequate storage conditions and consequent high levels of loss due to storage pests and other risks.

FIGURE 3.4. NOMINAL PRODUCER PRICES FOR KEY STAPLE CROPS (CFA/KG), 2000–13



Source: DAPS.

In terms of impacts, the high level of market dependency of the poorest households would suggest that an increase in the price of staple crops during the lean months would increase the proportion of households experiencing food insecurity, with consequent effects upon levels of malnutrition and associated morbidity. In practice, much greater fluctuations in prices are regularly observed (figure 3.4) and it is the profoundly negative ex post impacts of these fluctuations upon nutrition, health, and survival that result in staple food price shocks as being listed as the most important risk faced by rural households (see table 5.1).

Cash Crops

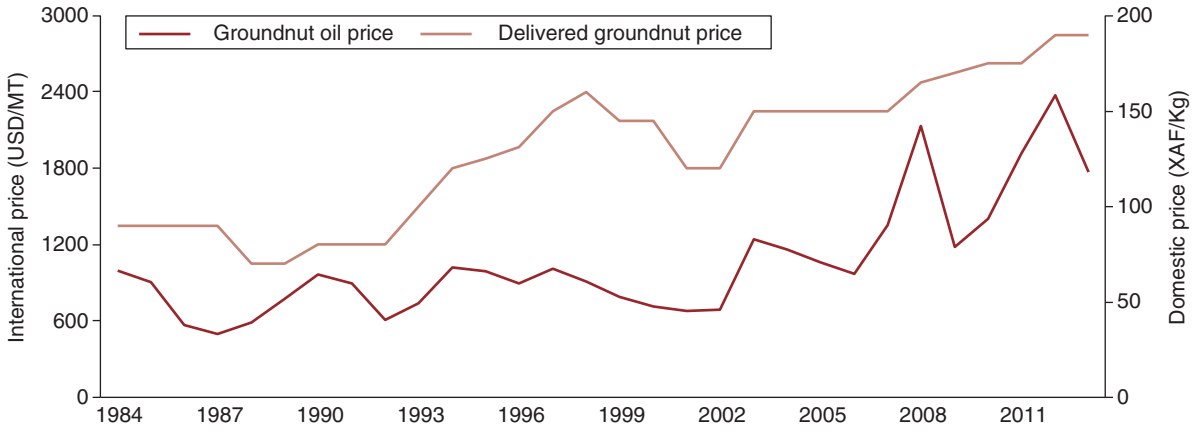
Because few producers grow cash crops without first securing their own supply through staple crop production, the risks to nutrition, health, and survival caused by fluctuations in cash crop prices tend to be less pronounced. Horticultural producers are a general exception to this because they typically produce fruits and vegetables exclusively for the market. Nevertheless, price fluctuations can contribute significantly to the risks faced by all stakeholders in cash crop subsectors. Although the production of export crops is vulnerable to price risk, the production of domestically marketed cash crops is subject to even greater price volatility. In the case of potatoes and onions, the seasonality of production combined with a lack of suitable storage infrastructure can result in a glut of these two commodities on the market leading to reduced prices and significant losses to both growers and traders. The impact of seasonality is exacerbated by the poor articulation of value chains whereby traders do not develop regular or contractual relationships with producers, but instead buy on an opportunistic basis so that prices are subject only to market forces, and when volumes are thin they can fluctuate considerably.

Groundnuts

Although growers of groundnuts may be confident that, because of the high political profile of the groundnut crop, the price negotiated at harvest time will be adequate to sustain their livelihoods, there is no guarantee that the negotiated price will be that which they ultimately receive. If the processors' margin between the agreed-on price for groundnuts and the international price for groundnut oil is inadequate, then processors may restrict or delay purchases. This has two effects. Intermediaries who have purchased groundnuts from farmers find themselves holding large stocks, either in warehouses or more commonly on trucks, for which they have no immediate market. The intermediaries' liquidity is thus dramatically reduced and their business effectively halted unless they can find alternative markets.

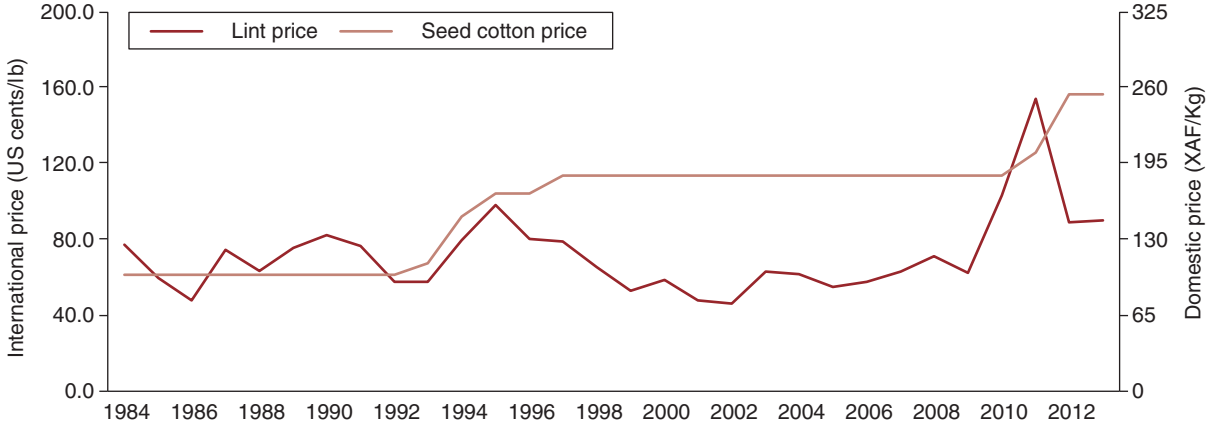
Producers selling directly to processors similarly find themselves unable to raise cash to meet their immediate needs. Because they generally lack storage facilities, they become vulnerable to postharvest losses unless they can otherwise dispose of their produce. The net effect is for both intermediaries and farmers to dispose of their groundnuts on the parallel market for domestic consumption at a reduced price. Although it might appear that the fixed price for groundnuts exposes the processor

FIGURE 3.5. INTERNATIONAL VS. DOMESTIC GROUNDNUT OIL PRICES, 1984–2013



Source: DAPS; FAOSTAT.

FIGURE 3.6. INTERNATIONAL VS. DOMESTIC COTTON PRICES, 1984–2013



Source: DAPS; Cotton Outlook Index A.

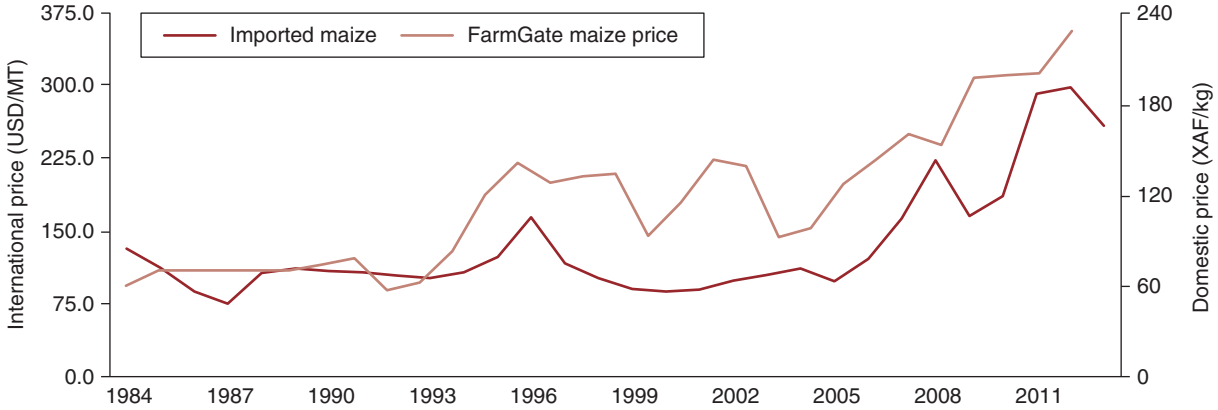
to price risk, the existence of a parallel domestic market and the effective oligopsony of three large groundnut processors, allows much of that risk to be passed back to the producers.

Cotton

The price for seed cotton is fixed at the beginning of the growing season by Société de Développement et des Fibres Textiles (SODEFITEX), which is the only buyer of the crop. Consequently, it is exposed to the risk of international price fluctuations for cotton lint until the ginned cotton has been sold. Moreover, to guarantee a minimum level of throughput, SODEFITEX is obliged to offer a price that is competitive with that for groundnuts. The company is thus limited in the extent to which it can factor the price risk into its buying price. Thus, for cotton, price risk is visited mainly upon the processing company. In practice, SODEFITEX is mandated by GOS to purchase all the cotton that is produced. Thus, it is unable to respond to anticipated price risk, and therefore bears the full brunt of unfavorable price fluctuations. The recent decline in the international price for cotton has led to the erosion of liquidity accumulated in the past when prices of cotton lint were significantly higher (figure 3.6). It is worth noting that unless prices rebound or financial support can be obtained, current dynamics may well render the company insolvent.

Since the mid-1980s, the international price index for cotton lint has generally varied between US$0.50–US$0.90 per pound (figure 3.4), although a major spike occurred in prices throughout 2011. The variability of international

FIGURE 3.7. INTERNATIONAL VS. DOMESTIC MAIZE PRICES, 1984–2013



Source: DAPS; FAOSTAT.

cotton prices over the past 30 years has been relatively high, with a coefficient of variation of 33 percent. By contrast, the international prices for both groundnut oil and for maize have been more variable with coefficients of variation of 44 percent and 45 percent, respectively (figures 3.5 and 3.7).

Maize

Maize prices in Senegal are determined primarily by domestic supply and demand. Although the country is not self-sufficient in maize (significant volumes are imported each year, mainly for poultry feed), domestic prices to farmers are generally lower than import parity, attributable mainly to the cost and difficulty of aggregating substantial volumes of consistent quality with which to manufacture animal feed. These same factors prevent the competitive export of maize. Producers of maize face only limited price risk (figure 3.7). The most common experience over the past 30 years has been for maize prices to spike upward rather than downward. The main risk due to maize price fluctuations is thus visited on livestock rather than maize producers.

The price risk faced by the companies that process locally purchased commodities for subsequent export (that is, cotton and groundnuts) is increased by the fact that the domestic purchasing price may vary independently of the export price, as a result of both the local price setting mechanism and of fluctuations in the exchange rate. By contrast, the export market for maize is negligible.

Both local production and imported maize are sold within Senegal and although domestic prices may not track international prices completely, the discrepancies between the domestic and international prices are much less marked than those of either cotton or groundnuts. Nevertheless, buyers of maize face only the risks of normal price fluctuations in either market.

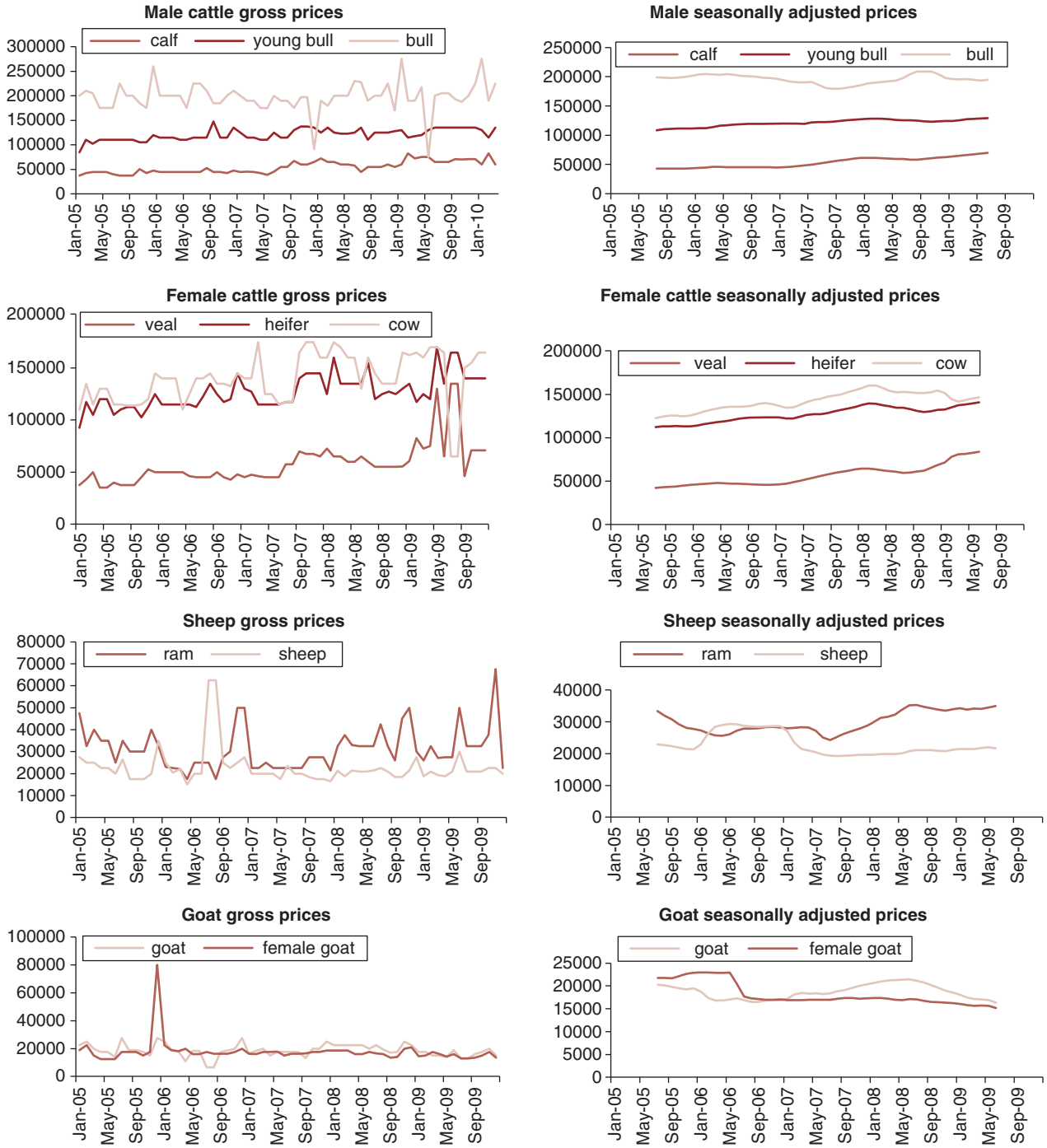
LIVESTOCK PRICE VOLATILITY

The limited reliance of pastoralists upon markets implies a limited impact of price risk upon pastoral livestock production. However, this situation is changing. In very traditional low-input, low-output pastoral systems, market dynamics were not a major concern and market risks were mostly of concern in commercial, intensive livestock production systems. However, the majority of livestock owners even in remote extensive systems are dependent on markets to some extent.

The relatively recent trend of growing involvement and dependence of pastoralists on markets is not without risks. These include market quarantines on animal sales because of disease outbreaks and food and feed animal price instability. During market shocks, livestock prices often plummet while food prices increase, which has now become a common shock-induced pattern in dry lands. The major reason that pastoralists of the Senegalese Sahel use livestock markets is to satisfy their own consumption needs, which usually are aggravated and increased during dry seasons and droughts (Wane et al. 2010).

Figure 3.8 shows seasonally adjusted prices for animals in Dahra, Senegal's primary livestock market. The cattle prices are stable in comparison with those of female goats and sheep, which tend to decrease while those from rams and billy goats are increasing. The trends in smallstock are

FIGURE 3.8. DAHRA MARKET LIVESTOCK PRICES (CFA/HEAD), 2005–10

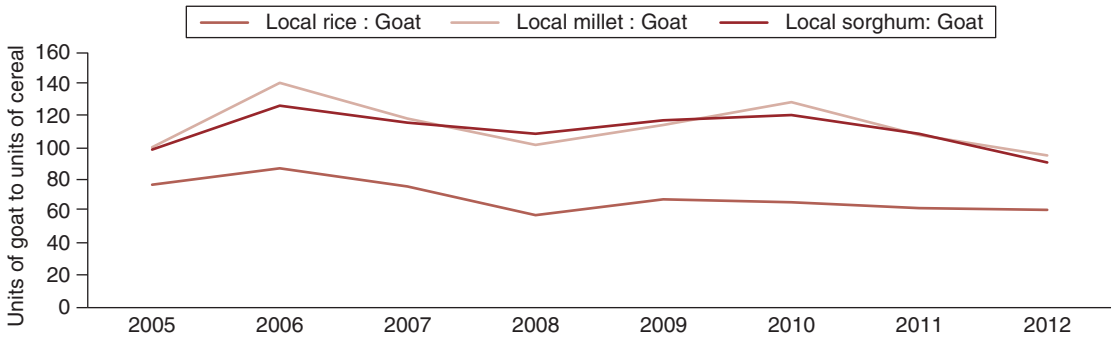


Source: Ministry of Livestock.

significant because of the number of animals being sold and their importance at the level of household income. Anecdotal evidence collected during this study would suggest that market parameters in Dahra depend to some extent on the dynamics of neighboring Malian and Mauritanian markets. Anecdotal evidence would suggest that the ongoing conflict in northern Mali has disrupted long-standing livestock flows and trade dynamics between the two countries, with observed decreases in the availability of animals for sale in Dahra in recent years.

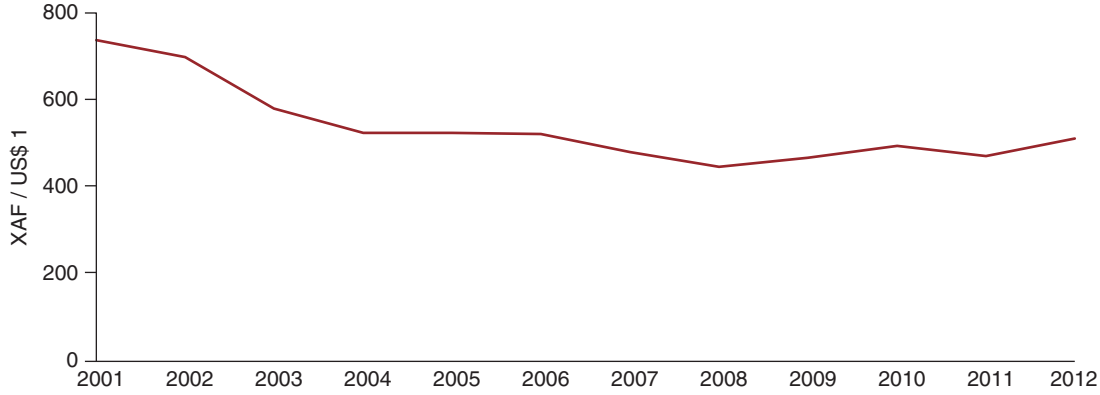
The most striking characteristic of the graphs in figure 3.8 is the notably high intra-annual variation in price. This is likely due to seasonality in demand (religious

FIGURE 3.9. GOATS VS. CEREALS TERMS OF TRADE, 2005–12



Source: Ministry of Livestock; DAPS.

FIGURE 3.10. HISTORICAL EXCHANGE RATES, 2001–12



Source: World Bank.

celebrations; buying male animals to plow land) and supply (willingness to sell to cover needs in dry seasons, and unwillingness to sell when conditions are good and herd rebuilding is taking place). It could also be due to disease outbreaks.

No national price data series for livestock is available. Nevertheless, figure 3.9 compares the annual average price for goats in the Saint-Louis region to average cereal prices for rice, millet, and sorghum. It illustrates that a goat bought more units of cereal in 2006 and 2010, but less substantially less in 2008 and 2012. Although 2006 was a drought year in Louga and Matam, 2008 and 2010 saw food and oil price shocks and the global financial crisis. Despite these observations, there are insufficient data to draw any firm conclusions.

Price volatility affecting imported feed components, notably corn and soya, which together make up 80 percent of poultry feed ingredients, can be considered the major risk facing Senegal's poultry industry. In the longer term, changes in international trade policies and trade embargos imposed in response to avian influenza constitute a major threat, with the possibility of cheaper imported poultry products from Brazil and the United States, in particular, undermining the economic sustainability of Senegal's emerging poultry industry.

EXCHANGE RATE VOLATILITY

Exchange rate fluctuations can also contribute to price risk for exporters of locally purchased products. The exchange rate of the XAF to the U.S. dollar has shown little erratic variation over the past 12 years, declining from XAF 750 in 2001 to XAF 425 in 2008 and remaining relatively stable thereafter (figure 3.10). Comparing the variation in international prices over the same period, it is evident that the risk due to unexpected variations in exchange rate has been relatively limited.

INTEREST RATE VOLATILITY

As elsewhere, poor access to credit is one of the principal constraints to agricultural growth in Senegal. This is especially true among the country's smallholder farmers.

Agricultural credit as a share of total bank credit (3 percent) in Senegal is among the lowest in the region. Much of this is used for purposes other than farm production, such as agro-food processing or storage. For example, a number of commercial banks finance the cotton and groundnut sectors in consortium with the agricultural bank Caisse Nationale de Crédit Agricole du Sénégal. For groundnuts, the bank's direct partners are processors, warehouses, and seed suppliers. For cotton, it is the processors and the national cotton producers' federation, the Federation Nationale des Producteurs de Coton. A relatively small number of smallholder farmers, mostly involved in commercial tomato and sesame production, are able to access seasonal credit via contract-financing arrangements.

For borrowers, high variability of interest rates can pose a risk to their enterprise when sudden spikes in lending rates can adversely affect resources and operations, and in extreme cases, cause them to default on their loans. However, in Senegal, such risks are minimal as the number of borrowers is small and interest rates have been relatively stable during the review period.

COUNTERPARTY RISK

In addition to price risk, producers, traders, processors, and others all face the risk of nonperformance by the other party in the course of a trade. Nonperformance in trade includes such occurrences as goods supplied underweight or below specifications, partial or delayed payment, or even complete failure to supply or make payment. The risk of nonperformance is generally higher when markets are poorly regulated. Although the level of market regulation in rural Senegal appears minimal, traders indicated that the frequency of nonperformance was low. They ascribed this to their own behavior in trading only with those whom they knew and trusted. Such a limitation of trading partners can reduce the efficiency of markets and increase transaction costs.

ENABLING ENVIRONMENT RISKS

Other sector risks arise from changes in the broader political and economic environment in which agriculture operates. These changes can be both internal and external. Agriculture sector policy and regulation are a source of risk when public involvement in sector activities has unexpected, adverse consequences. Other risks include general insecurity as a result of domestic unrest or regional conflict that can also disrupt agricultural production systems and livelihoods.

POLICY UNCERTAINTY

Within the context of an enabling environment, including the promulgation of policy and development and implementation of regulations, it is not the development of that environment per se, but the nature of stakeholders' perception of risk within it that is most critical to production. To that extent, any inconsistencies in policy or process can enhance uncertainty. Overall, the challenge to decision makers is that agricultural policy is obliged to reconcile the dilemma that although the development of the sector would benefit from higher commodity prices, the majority of rural households depend upon access to cheap food. This has led to inconsistencies in program implementation, which have been a consistent criticism of agricultural policy in Senegal (Resnick 2013). Indeed, the analysis highlighted a widespread perception among smallholders, pastoralists, and others that government interventions can increase the level of uncertainty associated with both crop and livestock production and marketing.

Over the past 20 years, GOS has consistently reduced its involvement in the agricultural sector. Exceptions to this have generally been positive for agriculture. Rice, maize, and cassava, in particular, have been the subject of special value chain development programs aiming to streamline interventions in these sectors and to intensify production.

For groundnuts, GOS policy has consistently been to set a processing price that will allow smallholders to make a profit. However, the single cotton ginning company SODEFITEX is also obliged to offer prices that are comparable in terms of ultimate earnings to discourage farmers from switching crops. As noted elsewhere, this policy exposes SODEFITEX to price risk when international cotton prices fall. For onions and tomatoes, GOS has introduced occasional import bans to support domestic prices during times of surplus. Nevertheless, the timing of the imposition and removal of such bans does not appear to be understood by stakeholders. There are no clear criteria for the changes in access, and the delay between the

announcement and implementation of such bans or their removal, which should be at least 120 days to allow growers to react, is often much less than this.

The analysis also highlights major concerns about land access, land tenure, and user rights of livestock owners. As in many arid countries where nomadic pastoralism and transhumance is important, the land tenure systems are pluralistic and complicated, and with increasing globalization and settlement often livestock owners' rights are not only not recognized but often not even understood. As such, large-scale land acquisitions, expanding agriculture and irrigation often take place without sufficient consideration of risks posed to livestock owners. There are very few cases in which such developments adequately address the pastoralists' needs. Such developments should not be outlawed, as they often increase primary production and can provide multiple opportunities for livestock owners; however, their design and implementation must be done in conjunction with all the stakeholders including pastoralists.

Livestock producers who provided input for this study noted, in particular, their concerns over access to land alienated under the Grande Offensive Agricole pour la Nourriture et l'Abondance for large agricultural projects, which had previously supplied dry season grazing and access to riverine pastures. The speed and lack of consultation associated with the process have engendered a perceived risk among pastoralists that their livelihood may be less sustainable than was originally understood. The lack of consistency in the application of regulations regarding animal movement in the event of disease, or even in the extent to which vaccination might be effectively carried out, also contributes to uncertainty that will constrain the extent to which livestock producers are willing to invest in production.

Senegal's existing trade embargo on imported poultry products protects the country's emerging poultry industry from the threat of avian influenza while keeping competition from lower-price imports at bay. However, there is strong international pressure from major exporters such as Brazil and the United States who charge the ban is unlawful and unnecessary. Although the legal procedures may take a long time to play out, there is a major risk to the whole viability of the Senegalese commercial poultry sector if GOS were to be compelled to lift the ban. In addition, uncertainty over how the issue will be resolved can adversely affect decision making and dampen investments.

Similarly, the analysis highlights weaknesses within the animal health service delivery system that merit added attention. Following structural reforms in the 1980s, livestock vaccination has largely been handed over to the private sector. Overall, livestock vaccination coverage has dropped to approximately 20 percent of smallstock and 63 percent of cattle, significantly short of the 80 percent coverage required. This gap substantially increases the risk of heavy losses when disease outbreaks occur. Quality control on the import, sale, and use of veterinary drugs is poorly monitored, contributing to added uncertainty over the efficacy of treatment and prevention programs at the farmer level.

Although private sector involvement is common in almost African countries, there remain questions about the economic viability of veterinarians operating in remote extensive pastoralist systems. Indeed, many of these private sector operators may not be operating within the nationally and internationally required norms. One private vet interviewed estimated more than 50 percent of drugs sold are counterfeit and 40 percent of chickens eaten by humans in Ndiaye show signs of antibiotic residues in meat. Table 3.5 illustrates the challenges of animal health service provision in Senegal, bearing in mind that to achieve effective disease control requires 80 percent vaccination coverage. There is a general recognition that implementation of the law is weak and chronically underfunded. The Ministry of Livestock requires a budget of CFA 3 billion (US$600 million) per year. It receives one-third of this amount, of which 60 percent is spent on vaccination. The Ministry also recognizes the noncompetitiveness of local vaccine production.

CONFLICTS, THEFT, AND INSECURITY

Where conflicts occur, unrestrained by the rule of law, then the impact of risk is considerable. Since 1982, the region of Casamance has been affected by internal conflict and tensions. An estimated 30,000–60,000 people have been displaced and agricultural production in Casamance reduced by 50 percent since 1985 (World Bank 2013). Senegal's richest agricultural region, Casamance is plagued

TABLE 3.5. VACCINATION COVERAGE IN SENEGAL, 2009

Aim/Objective	Population of Animals Targeted	Number Animals Vaccinated 2008–09	Animal Population Vaccinated (%)
Lumpy skin disease/dermatose nodulaire contagieuse bovine (DNCB), nationwide	3,136,500	934,057	29.8
Foot and mouth diseases/fièvre aphteuse	3,136,500	35,863	1.1
Specifically targeted exotic breeds			
Pasteurellosis bovine	3,136,500	70,456	2.2
Not nationwide, but many regions affected			
Horse sickness—nationwide	517,634	134,362	26.0
Peste des petits ruminants—nationwide	9,259,450	1,644,254	17.8
Newcastle disease (backyard and village level)	22,077,800	166,319	0.8
Botulisme—East and North Sénégal	465,600	48,531	10.4
Pasteurellosis in smallstock—paid for by livestock owners	9,259,450	43,454	0.5
Clavelée—paid for by livestock owners	9,259,450	35,708	0.4

Source: Gary et al. 2010.

with chronic food insecurity. In 2014, the region had the highest levels of hunger, with 37 percent of households, representing some 1.8 million people or 14 percent of Senegal's population, facing food shortages. Ten percent of households faced severe food insecurity. Food shortages in Casamance are often aggravated by the low-intensity rebellion by the Casamance Democratic Forces Movement (MFDC) that began in 1982 and, albeit infrequently, hampers agricultural transport, trade, and other socioeconomic activities. It has also restricted access to farms because of the proliferation of landmines. The most affected areas are in Sindian in northern Casamance and in the south near the border with Guinea-Bissau.

Conflict and tensions between herders and crop growers were highlighted as risks by several interlocutors during the field mission and are commonly stated in the literature as an increasing problem in the extensive Sahel pastoralist systems. Indeed, much of the conflict in the region (Central African Republic, Niger, Mali, and Darfur) can be traced back to divisions between farmers and herders and clashes over natural resources. Their frequent mention in Senegal is a notable concern.

The effects of conflict include reduced mobility by traders, veterinary auxiliaries, and private vets who are unable to reach livestock owners in time; seasonal labor movement and some agricultural activities are curtailed (for example, transplanting of rice, harvesting); access to markets is reduced and markets become less efficient. Moreover, government officials, vehicles and services are unable to reach these insecure areas, and vaccination and veterinary services are discontinued. For example, despite a major outbreak of LSD in 2008, few animals were vaccinated, leading to higher mortality rates. In addition, conflict leads to increased larceny and cattle rustling and a sense of impunity among criminals, increased violence and even death of livestock owners, as well as increased "unofficial" taxation by armed forces and others. It is worth noting that theft is not restricted to the Casamance region alone. Throughout the survey, the problem of theft was repeatedly cited by producers and traders.

CHAPTER FOUR
ADVERSE IMPACTS OF AGRICULTURAL RISKS

The frequency, severity, and costs of adverse events are analyzed in this chapter as the basis for prioritizing the various sources of risk. The conceptual and methodological basis described below is then applied to production, market, and enabling environment risks. The various sources of risk are then reviewed to discern the most critical.

CONCEPTUAL AND METHODOLOGICAL BASIS FOR ANALYSIS

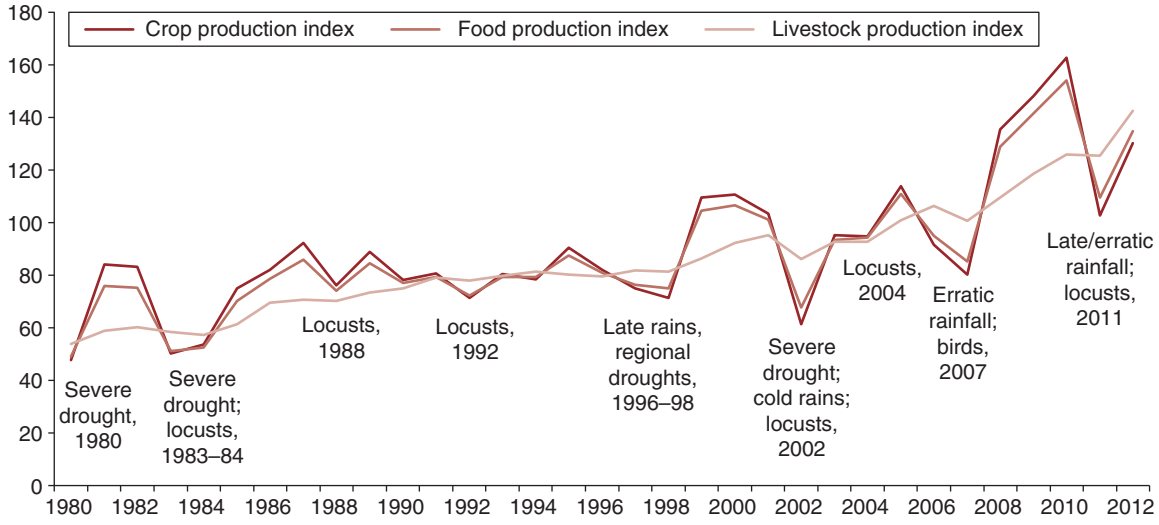
For the purposes of this study, *risk* is defined as an exposure to a significant financial loss or other adverse outcome whose occurrence and severity is unpredictable. Risk thus implies exposure to substantive losses, over and above the normal costs of doing business. In agriculture, farmers incur moderate losses each year as the result of unexpected events such as suboptimal climatic conditions at different times in the production cycle and/or modest departures from expected output or input prices. Risk refers to the more severe and unpredictable adverse events that occur beyond these smaller events.

This concept differs from the common perception of "risk" by farmers and traders, based on the year-to-year variability of production and prices. It should also be distinguished from constraints, which are predictable and constant limitations to productivity and growth and which contribute to inefficiencies in production and marketing systems.

LOSS THRESHOLDS

As agricultural production is inherently variable, the immediate step for analysis is to define *loss thresholds*, which distinguish adverse events from smaller, inter-annual variations in output. This is achieved by first estimating a time trend of "expected" production in any given year, based on actual production, and treating the downside difference between actual and expected production as a measure of loss. A loss threshold of 0.33 standard deviation from trend is then set to distinguish between losses resulting from

FIGURE 4.1. TIMELINE OF MAJOR SHOCKS TO AGRICULTURAL PRODUCTION IN SENEGAL (2004–06 = 100), 1980–2012



Source: World Development Indicators; Authors' notes.

adverse events and those that reflect the normal costs of doing business. Those below threshold deviations from trend allow estimation of the frequency, severity, and cost of loss for a given time period (see appendix D for illustrations of indicative crop loss estimates). The frequency and severity of losses derived in this manner were also checked against historical records to ensure consistency with actual adverse events.

THE INDICATIVE VALUE OF LOSSES

Available data on actual losses resulting from adverse events are not always accurate or consistent enough to facilitate comparison and ranking of the costs of adverse events. Analysis was thus based on estimates of the "indicative" value of losses, which provide a more effective basis for comparison. Indicative loss values are also compared with the value of agricultural GDP in the relevant year to provide a relative measure of the magnitude of loss. Although these estimates draw on actual data as much as possible, it is emphasized that they represent indicative, not actual losses.

DATA SOURCES

Analysis of this nature requires a consistent set of data on both production and prices for an extended time period. Of the various sources of data available, FAOSTAT's data series on the value of gross agricultural production (1980–2012) and crop production (1980–2012) was considered the most suitable. These data allow the analysis of risk over a 33-year period.

PRODUCTION RISKS

Based on analysis of available quantitative and qualitative data, the most common risks to agricultural production in Senegal are drought, locust outbreaks, and flooding. The incidence of these and other adverse events is indicated in figure 4.1, largely based on reports of adverse events for the period 1980–2012. During the 33-year period 1980–2012, Senegal's agricultural sector has been subjected to at least 10 major shocks. Erratic rainfall and drought emerge as the most common sources of production shocks, followed by locusts. Related risk events may occur in isolation, but can also present as multiple, overlapping shocks—as was the case in 1984, 2002, 2007, and 2011—with far greater impacts and higher associated losses.

Measured in terms of gross agricultural value,[8] crop production in Senegal was significantly reduced 11 times by adverse events during the period 1980–2012, for an overall frequency of one in three to four years on average (table 4.1). All but three of these events resulted in a drop in aggregate production value of 10 to 30 percent. It is worth noting that three (1980, 1983, 2002) of the four

[8] Gross aggregate value is the total value of volume of production for each crop multiplied by the producer price.

TABLE 4.1. COST OF ADVERSE EVENTS FOR CROP PRODUCTION,* 1980–2012

Year	Description	Indicative Loss Value	
		US$ (in millions)	% of Gross Prod. Value*
1980	Severe drought affecting 8 of 14 regions, incl. Kaolack, Kaffrine, Fatick; −333 K MT of gnuts	−128.2	−19
1983	12 of 14 provinces affected by severe drought; locusts; 340 K MT of groundnuts lost	−128.5	−19.3
1984	Regional droughts in Matam, Tambacounda,	−91.7	−13.8
1992	Regional droughts; locusts infestation; estimated 205 K MT groundnuts lost	−69.8	−10.5
1996	Regional droughts in Diourbel, Kaolack, Kolda	−50.3	−7.5
1998	Late, erratic rains; more than 172 K MT of losses in maize, millet, sorghum, cotton	−47.9	−7.2
1999	Delayed start to the season; erratic rainfall	−33.5	−5.0
2002	Severe drought affecting 50% of country; locust infestation; 420 K MT of groundnuts lost	−217.3	−32.6
2004	Locust infestation; over 133 K and 49 K MT of millet and cowpea lost	−68.6	−10.3
2007	Erratic rainfall; birds; substantial losses in millet, sorghum, maize, and groundnuts	−110.8	−16.6
2011	Erratic rainfall and locust outbreak affects maize, millet, and groundnut production	−97.7	−14.7

Sources: FAOSTAT.
Note: Cowpea losses were included from 1989 forward because of data availability. Potato losses were calculated from 1980 to 2004 because of inconsistencies in data thereafter.
*Average 2005–07.

years with the highest crop losses coincided with extreme drought events, whereas poor rainfall affecting key crop production areas coupled with locust and bird infestation contributed to high crop losses in 2007 and 2011.

Although figure 4.1 highlights the frequency of major risk events, it does not show the extent of the risk associated with individual crops in different provinces, nor the severity of the losses that have occurred. The degree of risk can be partially estimated from the variability of yield, as indicated by the coefficient of variation (table 4.2). This shows that maize yields are the most variable, closely followed by tomatoes, rice, and cowpeas. The variability of tomato yields is unexpected given the widespread use of drip irrigation to grow the crop and most probably reflects the impact of pests and diseases. Yield variation for millet and sorghum are the lowest among the crops assessed, as might be expected for crops that show a high degree of tolerance to moisture stress, whereas cotton, groundnuts, potatoes, and onions exhibit moderate levels of variability.

TABLE 4.2. COEFFICIENTS OF VARIATION FOR CROP PRODUCTION, 1980–2012

	Production	Area	Yield
Maize	0.70	0.36	0.38
Groundnuts	0.32	0.20	0.24
Onions	0.72	0.54	0.25
Rice	0.62	0.27	0.30
Millet	0.25	0.12	0.18
Sorghum	0.30	0.25	0.17
Cowpeas	0.68	0.51	0.30
Tomatoes	0.88	0.75	0.35
Cotton	0.36	0.25	0.24
Potatoes	0.33	0.32	0.26

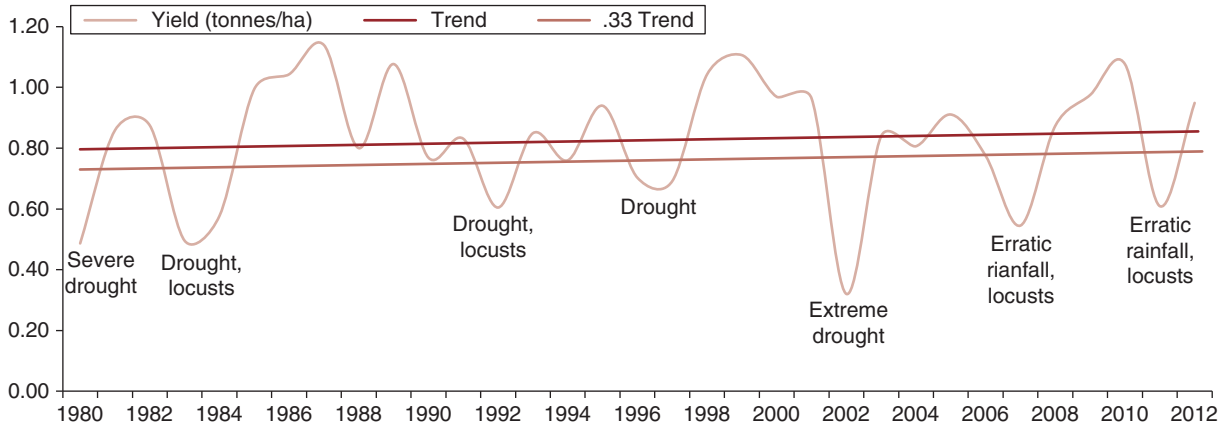
Source: FAOSTAT.
Note: For onions and tomatoes, 2012 was not available. Instead, data through 2011 were used.

Because it is based upon deviations from a trend observed at a national level, a national-level analysis may well underestimate the impact of risk events at the departmental level wherein the observed extent of variation can be

expected to be much higher. Moreover, the quantification of shock impacts is in fact a proxy measure of associated risk. The ex post impacts are but one aspect of risk that also affects production through its ex ante influence upon investment. Hence, absolute accuracy is less relevant as long as the relative impacts of different shocks are correctly assessed.

As an example, figure 4.2 illustrates the analysis of indicate losses for groundnut production at the national level during the period of review (1980–2012). The results suggest that over the 33-year period, shocks reduced production by 2.15 million metric tons (that is, an average of 6.4 percent of agricultural GDP in loss years). It is worth noting that the highest annual losses occurred in 2002 when the industry underwent a major restructuring with the privatization of Sonacos and the closure of its subsidiary, Sonagraines. This restructuring coincided with one of the worst droughts in 20 years and more than a 75 percent drop from peak output of more than 1 million MT two years earlier. It took another seven years (2009) before output would return to precrisis levels. The results

FIGURE 4.2. INDICATIVE LOSSES FROM RISK EVENTS TO GROUNDNUT PRODUCTION, 1980–2012



Source: FAOSTAT.

TABLE 4.3. INDICATIVE LOSSES FOR MAJOR CROPS, 1980–2012

Crop	Frequency	Production Loss (MT)	Value (US$, millions)
Maize	0.36	−388,459	−94.3
Groundnuts	0.30	−2,152,174	−635.2
Cotton	0.33	−102,795	−37.4
Onion	0.24	−131,867	−72.5
Tomato	0.27	−184,969	−33.0
Mango	0.42	−120,355	−47.8
Bean, green*	0.28	−16,173	−8.3
Millet	0.30	−998,878	−219.7
Sorghum	0.33	−250,622	−55.1
Rice	0.24	−335,423	−106.6
Cowpea	0.30	−136,503	−89.7
Total		−4,818,218	−1,402.4

Source: FAOSTAT.
Note: Price are averaged producer prices during 2005–07.
*Covers the period 1988–2012 only.

of similar analyses conducted for other staple food and cash crops are shown in table 4.2. The crop-specific analyses are summarized in appendix D.

The results of the trend analyses indicate that for the 11 target crops analyzed, the total cumulative loss of production over the 33-year period was approximately 4.82 million MT, with an estimated value of US$1.40 billion, or 3.9 percent of agricultural GDP on an average annual basis. Among crops, maize exhibited the highest level of vulnerability in terms of frequency, whereas groundnuts incurred the highest losses, accounting for nearly 45 percent of aggregate losses.

Though average annual impact of shocks on agricultural GDP is relatively limited (less than 4 percent on average), it is the relative impacts between crops that are of greatest significance. Thus, of the 11 crops assessed, shocks to groundnut production account for nearly half (46 percent) of the total ex post impact, reflecting the importance of that crop to national GDP. Despite its low coefficient of variation of yield, millet shows the greatest impact of shock after groundnuts. This again reflects the large area under cultivation, but it also reflects the higher variability of rainfall in the lower rainfall areas where millet production predominates. Among the other crops, maize and cowpeas show similar impacts in terms of the size of loss. The absolute volume of loss of cowpeas is relatively small, but the higher value of the crop results in greater losses. Relatively limited aggregate losses for cotton reflect both the relative tolerance of the top to erratic rainfall as well as the area under cultivation.

IMPACTS OF PRODUCTION RISKS

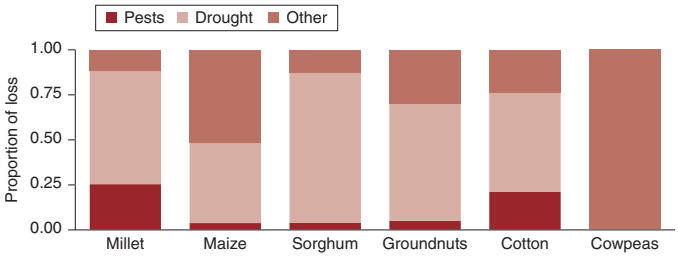
The attribution of yield loss to specific shocks is inevitably an approximation, but it is nevertheless useful to compare the losses experienced during different years and thereby to determine the relative impact of different risk events. Table 4.4 indicates the years when specific shocks occurred and their frequency over the period 1980–2012.

The frequencies calculated in table 4.4 can be combined with the yield loss data calculated from the trend analyses and other sources for each crop to indicate the proportional impact of different shocks on each crop. This analysis was done for the six main field crops (millet, maize, groundnuts, sorghum, cotton, and cowpeas) with results shown in figure 4.3.

TABLE 4.4. DATES AND FREQUENCIES OF AGRICULTURAL RISK EVENTS

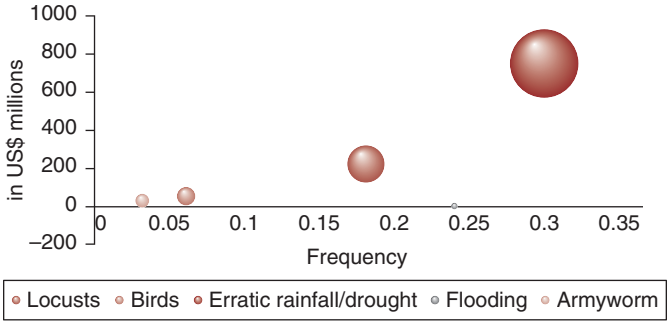
Risk Event	Year	Frequency (33 years)
Locusts (migratory locusts, grasshoppers)	1983–84; 1987–88; 1992; 2002; 2004–05; 2011–12	0.181
Birds	1994; 2007	0.061
Drought; erratic rainfall	1980; 1983–84; 1990; 1996–98; 2002; 2007; 2011	0.30
Flooding	1989; 1999–2000; 2003; 2005; 2008–09; 2010; 2012	0.27
Armyworm	2010–11	0.061

FIGURE 4.3. PROPORTIONAL IMPACT OF VARIOUS ADVERSE RISK EVENTS BY CROP, 1980–2012



The data show the relatively minor impact of pests (mainly locusts) and the dominant impact of drought (or more properly, drought and erratic rainfall). Significantly, although cowpeas experienced loss of yield in some years, such losses occurred when neither drought nor locusts were prevalent so that all losses appeared to have been caused by other factors.

FIGURE 4.4. FREQUENCY AND CUMULATIVE IMPACT OF VARIOUS ADVERSE RISK EVENTS, 1980–2012



Results of the analysis can also be summarized in terms of the frequencies and expected losses associated with the main risks to crop production (figure 4.4). The frequency of each risk is based on its occurrence during the period 1980–2012. The associated loss is an estimate of the indicative costs for each type of risk during the period of analysis. The graph clearly shows drought as the major source of risk, causing the highest losses. However, it is worth noting that all these events and associated losses occurred prior to 2003; there have been no incidences of widespread drought over the past decade. Locusts emerge as the next most important source of crop production risk after drought, whereas the high incidences of floods, particularly in the last decade, causes limited damage to crop production.

SUMMARY OF IMPACTS

There are insufficient data available to separate the different impacts of specific risk events/shocks with a high degree of accuracy, or to develop an accurate assessment of actual losses incurred because of these events at a local level. Nevertheless, it is possible to draw some broad conclusions from this analysis, namely:

- Adverse impacts on Senegal's agricultural production from risk events are equivalent to at least 3.9 percent of agricultural GDP on average.
- Senegalese agriculture is subject to losses exceeding 10 percent of gross production value in one out of every five or six years on average due to unmanaged risks.
- The most significant cause of loss is drought/erratic rainfall, which accounts for approximately 50 percent of crop yield reductions, particularly for groundnuts and cereal crops. Pests and diseases, especially locusts, account for a further 25 percent.
- Variation in price can be a significant risk to crop farmers, particularly horticultural producers, even when prices have been set by institutional buyers.
- For livestock producers, production risk is largely related to disease and to occasional devastating events such as cold rain.
- Market shocks can occasionally occur, but livestock producers are under less pressure to sell their produce than are crop producers, so the overall risk is less.

CHAPTER FIVE
VULNERABILITY ANALYSIS

All stakeholders in agricultural value chains assume some level of risk. Vulnerability presents when the potential impact of risk events is greater than a stakeholder's capacity to absorb adverse impacts. This may be because knowledge of the frequencies or impacts of risk events is inadequate (as a result, for example, of unforeseen changes in climate) or because actions that might otherwise limit the level of risk assumed are constrained by circumstances so that involuntary exposure to risk is increased. (This is especially true where capacity for adaptation lags behind changing circumstances.) A more comprehensive analysis of the factors contributing to vulnerability is presented in appendix C. Its key conclusions and relevance to different types of stakeholders are listed below.

Table 5.1 provides a simple ranking of risks reported by smallholders (Wane and Galandou 2012). The most oft-cited risk, reported by almost 50 percent of households, highlights their perceived vulnerability to food price shocks. This is indicative of high levels of market dependence because of insufficient productive capacity together with low levels of off-farm income. It is perhaps notable that the most important vulnerability is not to a risk inherent to agricultural production but to rural households as consumers. Initiatives designed to increase the prices paid for staple crops may well expose households to higher levels of vulnerability if not accompanied by other measures.

The second most oft-cited risk also relates to cash dependence and the limited financial resources of producers that constrain their capacity to deal with increases in the costs of inputs. It is again significant that although this shock does affect agricultural production, it is mediated through local input markets rather than through a physical event such as drought or disease. The same is true for the fourth most important area of vulnerability, that is, the loss of productive capacity through death, disease, or disability, which altogether affect almost 25 percent of households. These shocks may affect agricultural production, but the effect is not upon the agricultural production system itself.

It is only the third most frequently cited risk event (poor rains), reported by nearly one-quarter (23.8 percent) of households, that has a direct effect on agricultural production

TABLE 5.1. FREQUENCY OF RISK EVENTS AND PERCENTAGE AFFECTED

Type of Shock	No. of People Affected	Share of Total (%)
Rising prices of food	2,878	48.9
Increase in the price of inputs/farm equipment	1,891	32.1
Poor rains	1,402	23.8
Illness/accident of household member	1,221	20.7
Decline in the price of products sold by the household	560	9.5
Theft of property or animals	533	9.0
Animal disease/death of animals	468	7.9
Insecurity	455	7.7
Animal damage	439	7.5
Animal disease/death of animals (cattle)	407	6.9
Invasion of pests/granivorous birds	351	6.0
Diseases of plants	207	3.5
Loss of employment or unemployment	199	3.4
Floods	134	2.3
Fire/bushfires	74	1/3
Conflicts	72	1.2

Source: Wane and Galandou 2012; Authors' notes.

systems. Moreover, although the impacts of most of the subsequently listed shocks, including pests and diseases, theft, floods, and fires, also directly affect agricultural production, three of the four most important areas of vulnerability lie beyond agriculture and reflect inadequate household income on the one hand and limited health service capacity on the other.

Nevertheless, table 5.1 shows that rural households are vulnerable to a variety of agricultural shocks. In practice, that vulnerability has been reduced through a variety of practices that limit their exposure to risk. In an agricultural context, vulnerability to risk can be considered from the perspective of those practices and the extent to which they can be employed by different types of agricultural supply chain actors.

STAKEHOLDER AND LIVELIHOOD RISK PROFILES

This section profiles various types of agricultural stakeholders in terms of some of the key risks they face and their capacity to mitigate such risks and recover from related shocks.

PASTORALISTS

It is widely recognized that the least vulnerable of livelihood groups are the nomadic pastoralists, who although living in arid areas have adopted a lifestyle that enables them to mitigate the risk of drought by continually moving to areas of fresh grazing. Studies have shown that as long as the mobility of pastoralists is not constrained, their vulnerability to weather risks such as drought is low. However, if pastoralist herds are unable to move freely to new grazing areas, their chances of survival are substantially reduced. Ready access to animal protein contributes to a balanced diet, and the characteristic of livestock to maintain value allows them to be used as a source of finance that is both mobile and little prone to decay (in marked contrast to the production of crop farmers).

Nevertheless, the pastoralist livelihood is particularly vulnerable to four risks: namely, widespread (regional) drought, locust infestations, severe animal disease outbreaks, and constraints upon movement. The frequency of the first three risks is low, though ex post impacts of related shocks can be high. However, growing land pressures and other factors are increasingly inhibiting transhumance, and with that, the ability of pastoralist

households to mitigate risk and rebound from shocks when they manifest.

OTHER LIVESTOCK PRODUCERS

Livestock are raised by at least three other types of producers. Agro-pastoralists who are transitioning out of pastoralism are among the most vulnerable households. Such households generally possess few livestock and occupy lands on the margins of pastoral areas—lands that are inherently low in rainfall. These households are thus exposed to low and variable rainfall, but their sedentary lifestyle denies them the advantages of mobile pastoralism so that capacity for risk avoidance is limited. Few households adopt an agro-pastoralist livelihood by choice. Instead, they are obliged to do so by changing circumstances, especially reduced access to grazing. As a result, agro-pastoralists tend to be the poorest households, lacking the resources needed to absorb the impact of shocks, which further enhances their vulnerability.

Intensive livestock producers are constrained by the availability of land to support their livestock. They are obliged to use supplementary feed to fatten their animals, which are often kept in close confinement. The extent to which intensive producers are more or less vulnerable to risk than their extensive counterparts is debatable. On the one hand, the purchase of feed allows intensive producers to be largely independent of weather and grazing, whereas the confinement of livestock can reduce exposure to disease. On the other hand, a higher level of management is required to ensure consistent rates of growth and disease outbreaks, when they do occur, can be more debilitating than those experienced under extensive production. The greater level of investment into intensive livestock production systems also increases the potential vulnerability of producers who have more to lose in the event of a disaster. On balance, it would appear that whereas the impacts of risk events upon intensive livestock production may be greater than those experienced by extensive producers, most intensive producers have a greater capacity both to prevent such events and to withstand their impacts and are hence less vulnerable to the impacts of risk events.

Finally there are those smallholders whose main livelihood is derived from crops but who raise a small number of animals either for draft, for home consumption, or for cash. These smallholders make a significant contribution to the national livestock herd, but their vulnerability is related more to their cropping activities. Indeed, for these households, livestock may help to reduce vulnerability because they can be sold as a source of cash in the event of crop failure.

DRY LAND SMALLHOLDER FARMERS

The risk of inadequate moisture renders dry land smallholders more vulnerable to production risk than their irrigated counterparts. This is reflected in the lower levels of inputs applied to dry land crops. Not only does the lower anticipated average yield not justify the same level of investment, but also the increased probability of risk events that could result in little or no return acts as an additional hindrance to investment. From this perspective, the advantage of irrigation is not only that it allows greater yields to be achieved, but also that by enhancing certainty that such yields are attainable, it justifies a much higher level of investment into the crop. Thus, the impact of irrigation upon average yields is usually much greater than the yield increase that might be ascribed to the better availability of adequate moisture alone.

IRRIGATED SMALLHOLDER FARMERS

Generally, irrigated smallholder producers face far less risk of inadequate moisture than their rain-fed counterparts. They therefore can be considered to be less vulnerable. This is correct insofar as a given level of production is concerned, but it is not inevitably so. Growers of irrigated crops are often obliged to adopt a more intensive approach to production to generate the revenues needed to cover the cost of the irrigation systems. Whereas the greatest component of agricultural risk (insufficient moisture) may be controlled, the level of investment under irrigation is generally increased so that the overall risk may not be reduced unless all other potential risk factors can also be controlled. This implies the need for a high level of technical competence in pest and disease control and in overall crop management, as well as a greater capacity to manage losses when they do occur. From this perspective, the risk faced by a smallholder is not reduced through the

introduction of irrigation systems unless that system has low fixed costs and/or the smallholder possesses the necessary agricultural acumen to avoid losses caused by other risk factors such as pests, diseases, mismanagement, and market prices.

COMMERCIAL FARMERS

Commercial farmers face the same risks as smallholders, but their levels of vulnerability may differ according to the type of risk. On the one hand, access to paid labor and machinery can reduce exposure to some risks, whereas higher levels of savings can allow commercial producers to absorb the impacts of risk events. On the other hand, commercial producers face a greater level of market risk than their subsistence counterparts. In general, commercial production systems have an increased reliance upon management practices that reduce the risk of loss (including the use of insecticides and fungicides), but the overall increased intensity of production can increase vulnerability in the event of an unforeseen loss or a breakdown in crop protection practices.

PROCESSORS

Processors in Senegal include groundnut processors, millers, and cotton ginners. All of these are vulnerable to market risk because of increased local prices and/or reduced costs of competing imports. Cotton and groundnut processors are also vulnerable to the risk of aflatoxin contamination, which cannot be detected in the unprocessed materials but which can render the final products unsaleable if detected at a later date. Processors also face the risk of inadequate supplies because of either poor production or a redirection of inputs toward food crops for household consumption, especially after a poor harvest. In the case of groundnuts, in cases in which the buying price is predetermined, processors may also be vulnerable to political expediency that results in a price that is higher than the market can bear.

TRADERS

Traders are primarily vulnerable to risks caused by market uncertainty. In particular, whereas mobile phones allow traders good access to immediate price information, they have poor knowledge of market volumes or of the extent of production. As a result of this vulnerability, few traders are willing to accumulate large positions with the intention of selling at higher prices. The risk that they might not be able to sell their stock owing to declining prices or to the presence of other traders in the same market limits most traders to short-term back-to-back trades. Similarly, whereas traders might discover a higher price of a commodity in a remote area, they are unlikely to purchase and transport large volumes to take advantage of that market because they are uncertain that the potential demand will be great enough to justify the expenditure. As a result, most markets are both temporally and spatially fragmented so that both seasonal fluctuations and geographic disparities in prices can be significant.

INCOME LEVELS

Income level is a variable characteristic of many livelihoods that has a dramatic effect upon vulnerability to risk and is therefore worthy of consideration in its own right. Studies have shown that risk is perceived relative to one's capacity to absorb that risk so that for households of low income, the perception of a given risk is much greater than it is for those of higher income. This is particularly evident for agricultural households of limited resources, who might be obliged to pledge vital assets (such as oxen, donkey carts, or savings) as collateral for a loan to increase food production through intensification. The impact of a low yield that for such a household could result in a failure to repay and consequent loss of assets can be so debilitating that the loans are often refused. This behavior has led to the general observation that smallholder farmers are risk averse. This is not necessarily the case, a more accurate observation being that poorer farmers are risk averse.

CHAPTER SIX
RISK PRIORITIZATION AND MANAGEMENT

Previous sections have highlighted sources of risks that are pervasive across the Senegalese agriculture landscape. These risks are both numerous and complex. They manifest with varying levels of frequency and severity, and can cause substantial losses to crops and livestock, with profound short-term and long-term impacts on income and livelihoods. Putting in place effective risk management measures can help mitigate adverse impacts on agricultural supply chains and the livelihoods they support. However, it is virtually impossible to address all risks at once. Thus, it is necessary to prioritize interventions based on which risks occur most frequently and which cause the greatest financial losses.

RISK PRIORITIZATION

Using quantitative measures and anecdotal evidence collected directly from stakeholders, this analysis has evaluated risks for the crop and livestock subsectors. Owing to the lack of reliable data, some of the risks could not be quantified. In such cases, the assessment team relied more on qualitative measures. Based on the team's combined quantitative and qualitative assessment, table 6.1 prioritizes the most important risks. This prioritization was presented during a roundtable at MEF in Dakar on March 21, 2014. It provides a basic ranking of agricultural risks on the basis of the probability of the event occurring and the anticipated impacts in terms of financial losses. The identified risks located in the grayer areas represent the most significant risks.

Overall, this prioritization identified (1) erratic rainfall, punctuated by drought; (2) locusts; (3) price volatility; and (4) crop pest and diseases as the most important risks facing Senegal's agricultural sector. Parasitic weeds such as Striga, aflatoxin contamination (maize, groundnuts) and other postharvest threats, and livestock diseases were also deemed important, but to a lesser extent.

It is worth noting that incidences of drought have declined significantly within the most recent decade, but it remains unclear whether this change is temporary or rather the result of a shift in long-term weather patterns. Although an observed wetting over roughly the same period has led to recurrent flooding in many parts of the country, affecting urban and coastal areas, impacts on crop and livestock production have been limited at the aggregate level.

TABLE 6.1. RISK PRIORITIZATION MATRIX

	Negligible	Moderate	Considerable	Critical	Catastrophic
Highly probable		Tifa (R-I) Perceived inconsistency of policy (L)	Pests and diseases Striga (M,S) Price volatility (dom crops.) Newcastle (L)		
Probable	Birds (M, S) Bushfires (L)	Pests and Diseases (P, T, C, Ma) Erratic access to quality medicines/ vaccines (L)	Erratic access to quality inputs and services (M, S, G, Ct) Dom/Int'l price variability (R, Mz) Birds (R-I) Aflatoxin (Mz, G)	Erratic rainfall (S, M, R-R, Mz,C, G) Locusts Price Volatility (T, O, G, C) Pest/disease (R)	
Occasional	Termites (All crops) Theft (M, R-R, MZ, L) Absence of regional standards (R-I) Contract default/ counterparty risk (All crops) Fires (M)	Windstorms (M, S, R-R) Temperature variability (R-I) Floods (All crops) Regional conflict Release of Food stocks (R-I, R-R)	Price volatility for poultry feed	Localized Drought Cold season rains (L)	Severe drought
Rare					

Source: World Bank.
Key: Sorghum, Millet, Rice–Irrigated, Rice–Rain-fed, Maize, Tomato, Potato, Mango, Cowpeas, Groundnuts, Cotton, Livestock, Onion.

The above assignment of risk priorities is in part based upon the responses of stakeholders collected through interviews over the course of the assessment. From that exercise, it is possible to list the priority risks faced by each subsector (table 6.2). It is notable that only cash crop producers highlighted severe drought as the most important risk they faced.

The listing of priority risks clearly shows the major importance of erratic rainfall as the main risk and of drought as a more extreme but less frequent expression of the same phenomenon. After this, the other priorities vary among crops and it is hard to identify a consistent theme. However, the reporting of locusts as a primary, secondary, and tertiary threat would make this phenomenon the second aggregate priority for the agricultural sector. Beyond this point, aggregation of crop-specific risk loses meaning and the next level of priority could well be accorded to price volatility, pests, and diseases, and perceived inconsistencies in policy implementation in equal measure.

This prioritization exercise is based upon the direct impacts of risk events. The indirect ex ante impacts are less easily quantified, but can for the most part be considered proportional to the ex post loss of profitability. Thus, from the perspective of prioritization, an analysis of ex ante responses to risk is unnecessary.

AGRICULTURAL RISK MANAGEMENT

The various risk events that give rise to both ex post losses and reduced ex ante investment can be addressed at three levels, according to impact and frequency as shown in figure 6.1.

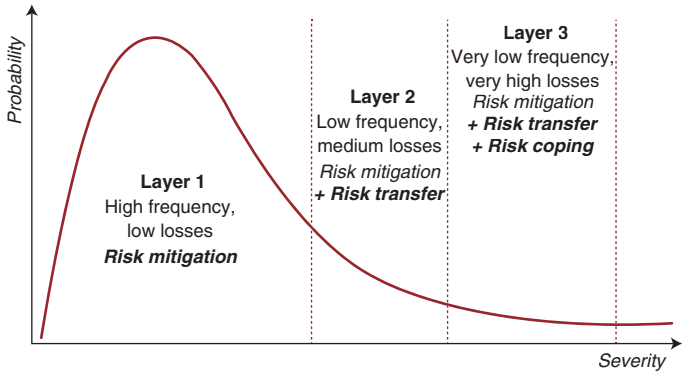
Risk mitigation—Responding to risk events of high frequency and low impact, the adoption of techniques or behaviors that reduce the impact of the event on production or profitability. Risk mitigation would include the

TABLE 6.2. LISTING OF PRIORITY RISKS BY COMMODITY

	Risk		
Commodity	**Priority #1**	**Priority #2**	**Priority #3**
Sorghum	Erratic rainfall	Locusts	Timely access to quality inputs
Millet	Erratic rainfall	Pests, diseases, and Striga	Timely access to quality inputs
Rice (Irrigated)	Bird damage	Price volatility	Water weed (Tifa)
Rice (Rain fed)	Erratic rainfall	Price volatility	Windstorms
Tomatoes	Price volatility	Inconsistent policy	Diseases and pests
Potatoes	Price volatility	Locusts	Disease/quality of inputs
Beans	Locusts	Diseases	Access to inputs
Mango	Drought	Locusts	Price volatility
Cowpeas	Erratic rainfall	Drought	Locusts
Groundnuts	Drought	Logistics breakdown	Disease
Cotton	Drought	Logistics breakdown	Locusts
Livestock	Erratic rainfall	Inconsistent policy	Poor policy implementation
Aggregate for Sector	Erratic rainfall/drought	Locusts	

Source: World Bank

FIGURE 6.1. INTEGRATED RISK-LAYERING SOLUTIONS



Source: World Bank.

development of irrigation systems to reduce the impact of drought, or the breeding and distribution of disease or drought-resistant crop varieties or animal breeds.

Risk transfer—Risk events of low frequency and medium impact can benefit from both risk mitigation and risk transfer, that is, the transferring of risk to third parties, either through insurance or through other financial mechanisms such as hedging (against currency risk) or the purchase or sale of futures contracts and/or options.

Coping Strategies—Risk of very low frequency and very high losses, strategies that are designed not to reduce or transfer the impact of risk, but to absorb it. For example, food-insecure households can be provided with food aid or cash, whereas others that may have taken out loans can in the event of disaster be afforded debt relief or debt restructuring. Coping strategies may be applied on an ex ante or ex post basis.

Potential responses to key risks are recommended on the basis of the above-referenced risk-layering approach.

Table 6.3 lists the proposed risk management mechanisms that are appropriate to the most significant risk events as defined by the combined impact of their frequency and extent of losses incurred. The majority of these are aimed at risk mitigation, although some coping strategies may also be required. The main risk transfer mechanism recommended is insurance, which not only can transfer risk impacts, but also can be used in conjunction with the coping strategy of debt relief. Moreover, it is appropriate that the recent introduction of parametric crop insurance in Senegal is closely linked to the provision of credit. A variety of coping strategies could also be leveraged. Many of these rely upon social protection mechanisms that may not be fully in place and will require development assistance to implement rapidly. It is notable however that almost all of the population of Senegal is dependent upon access to markets for some part of their food security so that rapidly implementable market-based solutions can be put in place

TABLE 6.3. PROPOSED RISK MANAGEMENT MECHANISMS

	Mitigation	Transfer	Coping
Drought	Promoting development of small-, medium-, and large-scale irrigation; water harvesting	Macro-level crop insurance	Use of weather index to trigger early warning and response
	Establishing and improving regional and national NDVI and early warning systems (EWS) linked to an effective and early emergency response system.	Farm-level crop and livestock insurance	Facilitating temporary migration and transhumance
	Improve or establish sufficient livestock related infrastructure: borehole, fodder reserves, roads, sale yards, abattoirs.		Contingent financing and other instruments to support coping measures
	Improve livestock feed and forage supply through either local provision or through subsidies, vouchers, and so on and developing community-level food and fodder/forage (that is, livestock) banks		Promoting development of social safety net programs (for example, food aid, Food-for-Work, Cash-for-Work)
	Commercial destocking		Livestock supplementary feed programs
			Debt restructuring/relief
Erratic rainfall	All the above drought mitigation measures, plus improved access to weather forecasts to inform and advise farmers on adequate time for cropping operations	Farm-level crop and livestock insurance	Promoting household/community savings
	Promotion of reforestation		Improved access to finance and micro-finance.
	Promotion of conservation farming technique		Debt restructuring/relief
	Improved access to drought tolerant and short season crops and varieties.		Facilitating temporary migration and transhumance
Locusts	Strengthening early outbreak detection/ response systems	Crop Insurance	Contingent financing and other instruments to support coping measures
			Promoting development of social safety net programs (for example, food aid, Food-for-Work, CFW)
			Debt restructuring/relief
Price volatility	Adoption of mixed farming and crop rotation	Hedging of currencies	Social safety net programs (for example, food aid, Food-for-Work)
	Promote the development of private sector aggregation points, warehouse capacity and cold storage facilities as well as the development of warehouse receipt and inventory credit systems	Use of commodity futures and options markets	Direct cash payments to affected households
	Enhanced domestic market capacity, including strengthening of market linkages and improved access to finance		Promoting household savings
	Access to credit during commercialization to avoid any sale		Substitutions and/or reductions in household diet
	Spreading production over time using appropriated varieties		
	Market regulation (import ban)		
	Improving harvesting quality and processing for longer conservation		

TABLE 6.3. PROPOSED RISK MANAGEMENT MECHANISMS (*Continued*)

	Mitigation	Transfer	Coping
Pests/diseases (crops)	Strengthening early outbreak detection/ response systems	Crop insurance (yield-based)	Developing social protection programs
	Promoting crop rotation and transition to more pest/disease resistant crops		Use of savings and borrowing
	Promoting IPM techniques		Direct compensation to affected farmers
	Diversifying seeds varietals within crops		Debt restructuring/relief
	Strengthening of P/D-tolerant seed development and distribution systems		
	Improving farmer access to agrochemicals		
Pests/diseases (livestock)	Biosecurity including active surveillance, vaccination and quarantine	Livestock insurance	Emergency vaccination and treatment programs
	Improved application of existing veterinary standards, laws and policies.		Direct subsidies, vouchers
	Training and capacity building of privatized and decentralized animal health services including vet vouchers		Quarantine
	LEGS[a] programming in planning		LEGS programming in responses
Inconsistent livestock sector policy formulation and implementation	Promote the development of business associations and advocacy groups to enable stakeholder and private sector participation in agricultural policy formulation		Establish clear emergency animal health response and declaration of emergencies
	Disengagement of government from market intervention		Capacity building, training
	Diversification of agricultural entreprises		Enforcement of rules and regulations
	Increased vertical integration within value chains		Linking emergency response to modern development policies.
	More transparent policy and better enforcement of existing policies and laws		
	Broader community involvement in land use plans to ensure access (forage, water)		

Source: World Bank.

[a] The Livestock Emergency Guidelines and Standards (LEGS) provide a set of international guidelines and standards for the design, implementation, and assessment of livestock interventions to assist people affected by humanitarian crises. Established in 2005, the LEGS Project is overseen by a Steering Group of individuals from the AU, FAO, the International Committee of the Red Cross, the Feinstein International Center at Tufts University, the World Society for the Protection of Animals, and Vetwork UK.

in the event of an unforeseen shortage in domestic production. Similarly, cash-based debt relief and restructuring initiatives can relieve the burden of risk events on households that have borrowed to invest in production.

RISK MANAGEMENT SOLUTIONS

The following discusses some of the broad intervention areas that the government could consider in responding to risks prioritized by this assessment.

IMPROVED WATER AND SOIL MANAGEMENT

There is one intervention that can truly mitigate the impact of drought, namely, total or supplementary irrigation, according to the circumstances. The introduction of irrigation to those areas where it is economically feasible and revitalization and maintenance of existing infrastructure should be viewed as a major priority, although earlier studies have suggested that the economics of irrigated production systems should be carefully scrutinized before development proceeds (Franzel 1979). In particular, irrigation per se is of

limited value if it is not accompanied by an increased intensity of production that allows the fixed costs of irrigation systems (especially their maintenance and management) to be met fully. This requires access to improved inputs, especially pesticides and fungicides, and the technical competence to ensure optimal yields at a much higher level of production than before.

From this perspective, the construction of a new irrigation scheme is less critical than the development (in the case of communal small-scale irrigation) of an effective water users' association and irrigation management structure, as well as ensuring both the supply of improved inputs and providing the necessary training to growers. Finally, not only must growers be able to access inputs and produce, but they should be able to market their increased production without difficulty as well. The new public-private partnership (PPP) program for staple crop-processing zones being undertaken by the Nigerian government is an example of such integrated market-led development.

From a policy perspective, the high priority of drought as a risk facing both crop and livestock producers requires conscious decisions to be made to achieve the best use of a limited resource (the irrigable land beside perennial rivers). On the one hand, it can be rendered extremely productive for crop production, albeit at considerable cost, whereas on the other, it can be critical to the survival of many pastoralists. It is difficult to reconcile these two priorities, but it is important to develop a land use strategy for such areas that will allow both crop and livestock producers to benefit from the limited resource. Unless such a strategy can be not only developed, but also agreed and adhered to by all stakeholders, there is a further risk of conflict and suffering.

The impacts of erratic rainfall can be mitigated not only by irrigation, but also by the small-scale adoption of water conservation practices. Nevertheless, it is the broad-scale adoption of two interventions that have the potential for the greatest impact, namely, conservation agriculture (CA) and the development of crop varieties bred for reduced drought susceptibility or drought avoidance. CA, or conservation farming, as practiced elsewhere in Zambia and Zimbabwe, has been shown to increase yields by (1) increasing soil water infiltration rates, and hence reducing runoff; (2) increasing root development so that each plant can extract nutrients from a larger volume of soil; and (2) promoting timely planting so that the crop can take maximum advantage of rains without becoming susceptible to moisture stress. The CA system can substantially improve a soil's capacity to absorb water and a crop's ability to extract it resulting in yield increases of 50 percent and more within the first year of implementation. It is also well suited for use in fragile soils that might otherwise be subject to erosion and degradation, since it minimizes cultivation so that soils are not left exposed to wind or rain erosion.

Almost all new technical interventions require the smallholder to apply additional inputs or labor and increase the cost of production and the risk associated with it. CA does neither. It allows for reduced labor and requires no increase in inputs (USAID 2013). From this perspective alone, it reduces risk to the smallholder, but the benefits of the technique are such that the risk associated with erratic rainfall is also substantially reduced. It is for these reasons that CF has achieved high rates (>90 percent) of sustainable adoption by smallholders (Kabamba & Muimba-Kankolongo 2009). GOS together with USAID have been promoting the establishment of CA since 2009. It is recommended that this initiative should receive greater support including the training of agricultural extension workers in CA and the promotion of its use among all smallholders that lack access to irrigation.

To maximize limited resources, farmers need good and timely information. For example, enhancing farmer access to weather forecasting information coupled with technical advice can greatly aid farmers in making better decisions, such as the most opportune time to plant. Similarly, as weather becomes more unpredictable, technical advice with regard to crop and variety selection can be customized based on anticipated rainfall patterns and amounts, helping farmers mitigate impacts.

STRENGTHENING SEED DEVELOPMENT AND DISTRIBUTION SYSTEMS

Demand for and use of improved seed varieties remains limited in Senegal. Enhancing farmer access to improved planting materials can greatly strengthen their ability to manage production risks. GOS and donors have invested substantial resources over the years in variety development, and seed multiplication and distribution projects. As a

result, seven seed production and processing centers and nine seed laboratories have been established across the country. Since 1989, the Senegalese government has gradually shifted to a private mode of seed multiplication and distribution. Today, groundnut seed is produced and distributed by a combination of parastatal and private entities, whereas millet seed is multiplied and distributed exclusively by individual farmers and farmers' groups or associations. Under the West Africa Agricultural Productivity Program (WAAPP), approximately 12,000 tons of certified seeds were produced over the past year, 2,000 tons of which were distributed to farmers in August 2014 when the rains failed.

ISRA has developed a number of improved seed varieties covering the country's main crops (that is, millet, groundnuts, rice, cowpeas, sorghum), including seven new varieties of millet and sorghum, which are either less susceptible to moisture stress or mature in a shorter period of time, reducing the probability that moisture stress could affect growth. Thirteen groundnut varieties have been introduced. Nevertheless, their availability among smallholders remains limited and adoption rates across many crops remains limited. Numerous instances of poor-quality or mislabeled seed were reported to the study team and it is evident that the seed multiplication and distribution system does not enjoy the full confidence of producers. In addition, lack of information and poor farmer access to certified seeds further constrain uptake. As a result, many smallholders use home-saved seed and do not benefit from ISRA research.

There is a clear need to improve the seed multiplication and distribution system with particular regard to the testing of seed to meet minimum germination and purity standards. The current system is not meeting the needs of farmers who noted that as a result, the purchase of seed has become in itself a risk for farmers. Support for increased testing capacity and stronger enforcement of the regulations regarding seed standards will encourage broader adoption of improved varieties by smallholders and help reduce farmer vulnerability to erratic rainfall and drought.

FASTER, MORE TARGETED LOCUST CONTROL

The impact of locust swarms can be visited upon all forms of agriculture, including field and horticultural crops as well as livestock. Risk management lies beyond the scope of the individual farmer who is obliged to rely upon national and international institutions to control this periodic pest. Nevertheless, it is a regrettable fact that outbreaks of locusts continue to occur and that a significant proportion of these remain—for diverse reasons—uncontrolled at an early stage (Lecoq 2010). The cost of control measures increases substantially as a locust swarm develops and it is therefore in the interest of all parties that initial identification and response should both be as rapid as possible. Continued support to the national locust control center in strengthening outbreak identification and response systems is essential, and programs such as the Italian Institute of Biometeorology's (IBIMET) collaboration with FAO/EMPRES to provide a meteorological information service to assist in the prediction of outbreaks will in the long term provide greater benefit than the (necessary) emergency responses that still remain typical of many donor interventions.

As a frontline country for locust control in Sahel West Africa, Senegal has already established autonomous national locust control units (CNLA) responsible for all desert locus control activities. With support from neighboring countries and from the African Development Bank, USAID, the World Bank, France, and FAO, GOS has equipped CNLAs to both prevent and respond to SGR outbreaks by building needed infrastructure and training technical staff. Such efforts merit additional support.

Over the past 10 years it has been recognized that the probability of locust swarms developing and their initial development can both be controlled through the use of pheromones and mycopesticides. There is also stronger recognition that locust control is not simply a matter of observation and reaction, but can be achieved through proactive IPM. This will require government support for the registration and production of biopesticides, as well as training in their effective use. The aim of a locust IPM is to manage locust populations so that uncontrolled outbreaks no longer occur. This requires continuous intervention, but may well be less costly in terms of control measures and will certainly be both more environmentally friendly, and more effective in terms of reduced impacts, than the more reactive responses that characterized the last locust invasions in Senegal.

UPGRADE CROP AND LIVESTOCK SERVICES

Both crop and livestock producers are faced with the risk of losses caused by pests and diseases. These are sufficiently frequent for them to be considered more as constraints than as risks were it not for the fact that they can be avoided. In practice, outbreaks of livestock and crop diseases are widespread and common, due in the case of livestock to inadequate institutional disease control systems (veterinary services, vaccination programs, and controls over animal movement) and in the case of crops to the slow rate of dissemination of disease-resistant varieties and to the high cost and limited availability of imported agrochemicals. Among both crop and livestock producers there is limited knowledge of disease control procedures as well as limited capacity to identify and react to insect pests in a timely fashion.

Although public spending on the agricultural and livestock sectors exceeds 10 percent of the national budget, the current impact of agricultural extension and veterinary services does not reflect this expenditure. Instead, producers face a level of risk from pests and diseases that could be significantly reduced through improved agricultural extension and veterinary services. Improper animal disease control, in particular, has a substantial impact on production and productivity and public health and contributes to increased pandemic risks.

Mitigation of disease risks is largely through raising awareness, good public hygiene, effective quarantines and vaccination programs, promoting good agricultural practices, and capacity building at the farmer level. In the case of poultry, the intensive or industrial production system also mitigates risk through good biosecurity and hygiene. The Senegalese government's decision to ban poultry imports in 2005 following the avian influenza outbreak, although supporting the growth of its domestic poultry industry, has remained the country's principal mitigation strategy against the disease.

The privatization of veterinary services has taken place without fully understanding the economic viability of such an approach. This has led to very low levels of coverage in the extensive livestock system, creating not only a higher likelihood of disease outbreak but also a significantly greater risk of higher losses when outbreaks occur. Such low coverage levels means that diseases will not be eradicated and, indeed, in recent years Senegal has seen a resurgence of CBPP, which once had been eradicated within Senegal's borders.

Improved service delivery could be achieved in a number of ways, including the use of PPPs and/or of paraveterinarians, but in all cases it will be critical that government should provide a level of oversight that can ensure performance. Currently, this is not the case. The study heard that those tasked with providing services frequently fail to do so, but continue to receive remuneration, suggesting that the strengthening of agricultural and livestock extension management systems could significantly enhance performance and reduce risks to stakeholders.

IMPROVED MARKET EFFICIENCY

A key area of uncertainty is that of price, which varies substantially both within and between seasons. Those institutions (such as the groundnut processors and SODEFITEX) that buy on the local market and sell internationally could reduce price risk through the use of mechanisms such as hedging, futures contracts, and the purchase of options. The greater risk, however, is to the smallholders and livestock producers as well as traders who sell and buy on the domestic market in which no such mechanisms exist. The uncertainties of the market reduce the extent to which traders in particular are willing to take a position and thereby limit selling opportunities for producers as well as contributing to increased market fluctuations. Such uncertainties could be reduced through enhanced market regulation, including stronger enforcement of existing performance requirements, more rapid dispute resolution, and strong adherence to competition law.

There are a number of mechanisms that can enhance market efficiency, including the development of warehouse receipt systems and improved dissemination of production information (price information travels freely and rapidly through the mobile phone network). In the livestock sector, support for commercial destocking exercises

through the development of market linkages has proved effective in stabilizing prices, although such exercises must be carefully managed to avoid market disruption. Overall, however, it is the general performance of the market as a result of its inadequate regulation that is the key cause of uncertainty. Regional, departmental, and arrondissement authorities all have a role to play in effective market regulation, and strengthening at all levels will help to enhance market performance and reduce price and other market risks facing stakeholders.

Additionally, there is a need to strengthen existing value chains within the livestock sector. This requires increased commercialization and market orientation as well as capacity building at all levels, including support for improved market access and strengthening of market information systems.

IMPROVING THE ENABLING ENVIRONMENT

This study noted the perception of uncertainty among stakeholders in terms of policy and/or policy implementation. Although the cause could not be accurately determined, the existence of the uncertainty was quite evident. Stronger stakeholder participation in the development and implementation of market interventions and of other legislation and regulations affecting the agricultural sector would help to reduce this uncertainty. It is recommended that greater support be given to the development of producer and marketing associations and advocacy groups. Although such institutions are indeed involved in the negotiation of groundnut prices, there is a wider role to be played in determining the nature, extent, and timing of other interventions. This will help to develop a stronger partnership between private sector stakeholders and government so that the perception of inconsistency in policy can be effectively reduced.

For the livestock sector, in particular, policy initiatives in the past and uncertainty over current GOS policy as well as perceived weakness in the capacity of government to implement regulations continue to have adverse impacts on livestock husbandry. Policies that led to changes in land use in the 1960s and 1970s alienated key grazing areas from livestock owners who traditionally had user rights to the land. Land zoning in the Senegal River Valley is supposed to protect such loss of land. However, recently, further use of grazing land for cropland expansion purposes can be observed. If livestock owners and other stakeholders are all fully involved in the process, such changes may not necessarily constitute risk, but there are many examples in which only elites or community representatives are involved in planning and decision making, leaving the vast majority out of the process.

Knowing that farming and livestock keeping in non-equilibrium Sahelian environments entail high risk, to create an enabling environment there must be policies and structures that build resilience, include early warning and early response, and can link and integrate long-term development approaches and actors to short-term emergency responses.

SOCIAL SAFETY NET PROGRAMS

Social protection programs can be an integral part of effective agricultural risk management. They often focus on speeding up postshock recovery but can also aid in supporting mitigation strategies. Such programs can take many forms, and can be especially transformative when resources are channeled into strengthening ex ante resiliency. They can include Food-for-Work programs that provide relief while facilitating the recovery of affected communities and enhancing their future resiliency. They can include programs that promote household savings to direct ex post cash payments and food aid delivery to affected communities. The World Food Programme's Food for Assets programs (2005–10) supported 37,000–209,000 beneficiaries a year in 14 departments and seven regions via food security analysis and community-level targeting. Participants received a combination of food and other incentives, such as training and seedlings, for asset construction during the lean season (WFP 2014). Other social safety net initiatives can include construction of community-level food and fodder banks that can greatly enhance access to food and livestock feed in times of emergency while speeding up food distribution and relief efforts. GOS is currently developing a social safety net system as part of a national social protection framework, and a National Cash

Transfer Program (PNBSF) targeting poor and vulnerable households.

DEVELOPING INSURANCE MARKETS

The government of Senegal has long recognized the importance of agriculture insurance to protect rural households from disasters. In 2008, it created the Compagnie Nationale d'Assurances Agricole du Sénégal (CNAAS) as a PPP together with the country's insurance industry. Today, CNAAS offers a wide range of products to farmers and herders, but will need substantial growth and product evolution to have a significant impact in addressing smallholder vulnerability and protecting their assets. Ongoing government support such as premium subsidies (GOS contributes 50 percent of the premium) and tax exemptions are powerful stimulants but leave room for further strengthening.

The experience of CNAAS in serving smallholders has benefited from a number of private sector pilot projects centering on index insurance, supported by the World Food Programme, World Bank Group, USAID, and other donors. They provide important proof of concept for innovative approaches to agriculture insurance, but cannot aspire to reach substantial numbers of farmers or herders in the absence of a more coordinated and strategic approach.

Public-private partnerships allow the private sector to provide services that a government might wish to offer, but in which it lacks the necessary expertise to undertake efficiently. Agricultural insurance is well suited to be undertaken by a PPP, which can maintain commercial objectivity while allowing for subsidization as necessary. If well implemented, such a program could help support, when implemented in complementarity with other risk management measures, substantial increases in productivity. The challenge is to provide coverage to smallholders across wide areas without incurring excessive costs of administration. Parametric insurance programs are designed to achieve this, but require a level of geographic resolution commensurate with local variations in soil type and climate if the system is to be effective. This may become increasingly possible as costs of technology decrease, but beneficiary responses suggest that the process remains in development.

PRIORITIZATION OF RISK MANAGEMENT MEASURES

Most all of the measures outlined above are complementary in nature and have potential to contribute to improve agricultural risk management systems in Senegal in the short, medium, and long term. However, decision makers in often resource-constrained environments are compelled to find the quickest, cheapest, and most effective measures among myriad policy options. Ideally, a detailed, objective, and exhaustive cost-benefit analysis will help in selecting the most appropriate intervention options. But conducting a cost-benefit analysis of so many different options can often be a costly and time-consuming process.

The use of decision filters is an alternative approach to evaluate and prioritize among a lengthy list of potential interventions. This can aid decision makers in making appropriate resource allocation decisions more expediently and more cost effectively. The following decision filters were developed and used by the World Bank team. The study team applied these filters to facilitate a rapid assessment to obtain first order of approximation, based on its assessment of the situation in the field. Whatever the filtering process and criteria adopted to evaluate decision options, it is important to ensure their clarity and consistency.

Table 6.4 describes the basic filtering criteria the assessment team used to rate each intervention, based on a scale of 1 to 5 (1—No; 2—marginally; 3—somewhat; 4—yes; 5—absolutely).

GOS has a long track record of investing in risk reduction. In recent years, Senegal has adopted a broad array of measures toward increasing capacity around Disaster Risk Reduction (DRR). Such measures include the creation of the Directorate of Civil Protection (DPC), the development of a National Platform for DRR, and the elaboration of a National Action Plan on DRR (2010–15). Senegal also participates in the recently launched, EU-led Global Alliance for Resilience Initiative (AGIR), a regional response to chronic food and nutritional insecurity across the Sahel and is a member of the Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS). These and other initiatives are primarily

TABLE 6.4. FILTERING CRITERIA FOR RISK MANAGEMENT SOLUTIONS

Criteria	Description
Applicability to current agricultural policy/programming or business objectives	Public sector: Is the proposed solution in line with current/existing agricultural policy/programs/priorities and so on? Private sector: Is the proposed solution in line with current/existing business objectives, and so on?
Feasibility of implementation	Is the proposed solution "easy" to implement in the short to medium term?
Affordability of implementation	Is the proposed solution affordable to put into action/implement?
Scalability of implementation	Is the proposed solution easy to scale up/make available to an increased number of beneficiaries?
Long-term sustainability	Is the proposed solution sustainable in the long term?

Source: World Bank.

focused on emergency rescue and response support to victims of disasters, rather than actual prevention, preparedness, and mitigation measures.

In 2006, Senegal finalized its National Adaptation Programme of Action (NAPA) for climate change adaption. Under its NAPA, Senegal identified saltwater intrusion, coastal zone inundation, drought, storm surges, and extreme temperatures as urgent climate-related hazards that called for immediate action. In looking at areas of vulnerability and possible adaptation options, Senegal's NAPA focused on the water resources sector, the agriculture sector, and coastal zones. In line with these principal hazards and areas of concern, Senegal's NAPA prioritizes adaption projects related to the development of agro-forestry, programs to promote the rational use of water, protection of the coastline, and programs to raise awareness and educate the public on related issues.

Other initiatives are not new and have been adapted over the years to meet the shifting risk landscape. For example, to help pastoralists cope through drought periods, the GOS's Opération Suvegarde du Bétail (OSB) protects the most sensitive categories of livestock species (for example, lactating females, calves, and animal traction animals) by distributing subsidized animal feed during emergencies to vulnerable areas. In March 2012, the GOS bought over CFA 3.5 billion of animal feed from national industrial mills and distributed it at a 50 percent subsidy, thereby encouraging the establishment of community-managed "animal feed" banks. Launched in July 2008, the Fonds d'Appui à la Stabulation (FONSTAB) contributes to the modernization and intensification of animal production by promoting infrastructural and process upgrade investments. These include the acquisition of equipment for the production, processing, packaging, and marketing of animal products; the provision of fodder crops; and the installation of artisanal, semi-industrial, and industrial units for the modernization and intensification of livestock production. Launched in February 2014, GOS's newest initiative, the National Agro-sylvo-pastoral Development Fund (FNDASP), aims to promote broader dissemination of technological innovations through value chain approaches, producer training, institutional support, and funding for research programs.

These and other GOS and donor initiatives are already helping to address vulnerabilities and strengthen the resiliency of the agricultural sector. And yet, as highlighted by this report, agricultural supply chains in Senegal remain highly vulnerable to a wide range of risks that jeopardize rural livelihoods. The current study highlights the need for a more targeted and systematic approach to agricultural risk management in Senegal.

Based on an analysis of key agricultural risks, an evaluation of levels of vulnerability among various stakeholders, and the filtering of potential risk management measures, this assessment makes the following recommendations for GOS's consideration. The proposed focus areas of intervention encompass a broad range of interrelated

investments, which together hold strong scope strengthen agricultural risk management systems and improve agricultural resilience in Senegal.

1. Strengthening extension delivery systems (for example, face-to-face, farmer-driven, ICT-based) for improved farmer access to technology and agronomic advice on improved soil, water, and pest management practices (for example, Conservation Agriculture, IPM).
2. Promoting improved water management measures (for example, water pans, roof and rock catchment systems, subsurface dams) and micro-irrigation technology (for example, drip irrigation) via community-led initiatives (for example, cash/Food-for-Work programs).
3. To further reduce rainfall dependency and better exploit existing water and land resources, promoting expansion of irrigation infrastructure.
4. Promoting use of contour erosion and fire barriers, cisterns for storing rainfall and runoff water, controlled/rotational grazing, grazing banks, homestead enclosures, residue/forage conservation, and other Sustainable Land Management (SLM) practices to reverse degradation of water, soil, and vegetation cover ensure sustainable access to grazing land.
5. Establishing and improving regional and national NDVI and early warning systems and farmer training linked to an effective and early emergency response system for drought and locust outbreaks.
6. To improve decision making among farmers and pastoralists and attenuate price volatility, strengthening the quality and access to needed agricultural information, including weather forecasting, extension advice and innovations (that is, seeds, water management), input/output prices, and so on for improved decision making.
7. Strengthening seed distribution systems, vaccination programs, and animal health services through improved monitoring and enforcement of existing quality control regulations governing product and service delivery, institutional capacity building, reform measures, and so on.
8. Building resiliency in northern pastoralist zones via more broadly inclusive policy making based on land administration for improved mobility and access, and development of community-driven feed/fodder production and storage centers.

CONCLUSION

This Phase I assessment assesses agricultural risks and impacts during the period 1980–2012. By documenting and analyzing how Senegal's agricultural economy has been affected in the past by risk events, the study has generated insight into which sources of risks are most likely to affect the sector and dependent livelihoods in the future. By prioritizing risks, the study can help GOS focus attention and resources on a smaller set of key risks that are having the most adverse impacts on production yields, incomes, and livelihoods. The study suggests a framework for the development of a more comprehensive, integrated risk management strategy to strengthen existing mitigation, transfer, and coping measures in Senegal. Finally, it provides a filtering mechanism to aid in the selection of a set of strategic interventions for improved agricultural risk management.

The assessment recognizes that many of the proposed strategies may already be covered to varying degrees under existing risk management programs. Others may currently be in the process of implementation, either by government agencies or by donors. Moving forward, the Phase II Solutions Assessment will analyze the effectiveness of existing programs, identify and assess challenges impeding their effectiveness, and outline strategies for scaling up effective interventions to reach a larger number of beneficiaries. This follow-up activity will place strong emphasis on ensuring a more coordinated, integrated approach to risk management in Senegal to ensure more effective and meaningful risk reduction and resilience building across the sector.

It is hoped that the findings and conclusions of this assessment will help to contribute to the existing knowledge base regarding the agricultural risk landscape in Senegal. It is also hoped that the study will help to inform a dialogue moving forward between the GOS, the World Bank, and GOS's other development partners that will lead to concrete interventions toward improved agricultural risk management and stronger resilience among stakeholders in the years ahead.

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APPENDIX A
CLIMATE CHANGE IMPACTS ANALYSIS

INTRODUCTION

Climate change is a long-term trend that will exacerbate natural resource constraints on agricultural production in Senegal by making weather patterns more variable, and increasing the frequency and intensity of severe weather events. As result, climate change will directly affect the incidence of some agricultural risk events and indirectly affect the incidence of others. Understanding how climate change trends affect farm productivity is essential to formulating an agricultural risk management plan that maximizes the use of scarce resources. Regardless of the future extent of global warming, identifying and implementing risk management strategies that address agricultural risks, including those exacerbated by climate change, can reduce volatility and improve sustainability in the sector.

VULNERABILITY TO CLIMATE CHANGE

In the *Mapping the Impacts of Climate Change* index under "Agricultural Productivity Loss," the Center for Global Development ranks Senegal sixth out of 233 countries globally for "direct risks" due to "physical climate impacts" and 23rd out of 233 for "overall vulnerability" due to "physical impacts adjusted for coping ability" (Wheeler 2011).

Like most of the countries in the Sahel region, Senegal's agricultural sector is highly vulnerable to the effects of climate change. The country's climate is already characterized by high temperatures and low, highly variable annual precipitation, factors that negatively affect the productivity of heat-sensitive crops. More than 95 percent of the total cropped area depends on rain-fed systems, and most farmers and herders practice traditional forms of agriculture (Khouma et al. 2013, 319). Because of these factors and the importance of the sector in Senegal's national economy, climate change impacts on crop yields and land suitability will have far-reaching effects.

The agricultural sector accounts for approximately 15 percent of GDP and is an important source of foreign exchange earnings. Agriculture also plays a key role in

poverty reduction and food security through its contribution to livelihoods. The sector employs 77 percent of the workforce and generates 55 percent of national grain requirements (IFPRI 2012). Although Senegal is a net food importer, domestic production is an essential source of household food consumption, especially in rural areas. In 2009, the average Food Self-Sufficiency Rate was 86 percent for millet/sorghum but just 39 percent for rice (IMF 2010), which constitutes a larger share of total cereal consumption in urban households (54 percent) compared with rural households (24 percent) (USAID 2013b).

PATHWAYS OF IMPACT

Climate change affects agriculture through temperature increases, changes in precipitation, and increases in the frequency and severity of extreme weather events. There are direct impacts, such as changes in land suitability for crops related to temperature changes, and indirect impacts, such as changes in food prices that ultimately affect food demand and well-being. Models predicting the effects of climate change on agriculture vary across regions and crop/livestock sectors, and depend heavily on the underlying assumptions. The projected effects of changes in precipitation are particularly difficult to reconcile given the vast regional variation in annual rainfall and limited district-level data. Rising temperatures are also expected to increase evapotranspiration, offsetting productivity gains. Although there is a large degree of uncertainty about the magnitude of impact, this appendix synthesizes existing climate projections and crop forecasts, highlights areas of consensus between different studies, and identifies areas of disagreement.

PRINCIPAL FINDINGS

TEMPERATURE

Temperature changes over the past 40 years have been faster in Senegal than temperature changes globally. Since 1975, temperatures have increased by approximately 0.9°Celsius (Funk et al. 2012), and downscaled general circulation models (GCMs) predict future increases in the average daily maximum temperature during the warmest month of at least 1°C to 1.5°C (Jalloh et al. 2012). The rate of warming is higher in the interior regions than in the coastal region, and all projections indicate that the frequency of extremely hot temperatures will increase (McSweeney, New, and Lizcano 2010).

PRECIPITATION

In contrast to the general consensus on rising and extreme temperatures, models of future rainfall conditions in Senegal predict varied outcomes. There is no consensus on the magnitude of change in precipitation, and little agreement on the direction of change in different regions, although model projections trend toward decreases in mean annual rainfall. According to a multimodel United Nations Development Programme (UNDP) analysis, projected annual change in rainfall ranges from −38 to +21 percent by the 2090s, and the mean annual change predicted ranges from −18 to +7%. In sum, different models predict a wide range of scenarios for large parts of Senegal.

There is broad agreement across models that precipitation extremes will be more frequent, increasing the incidence of droughts and floods (IPCC 2007). Most models also predict an increase in the intensity of high-rainfall events, and greater variability in the onset and cessation of the rainy season (Sene et al. 2006). These factors would negatively affect agricultural production, especially in regions where precipitation is already highly variable.

LENGTH OF GROWING PERIOD

The length of growing period (LGP) is a key determinant of land suitability for agricultural production, and is defined by the average number of days per year when average air temperature and evapotranspiration rates are conducive to crop growth. In central Senegal, a large area is expected to flip from an LGP greater than 120 days in the 2000s to an LGP less than 120 days by 2050 (Erickssen et al. 2011). The 120-day threshold is significant because cultivating crops like maize is considered very difficult below this threshold.

AREAS OF UNCERTAINTY

- Extent of crop yield increases due to CO_2 fertilization
- Extent of increase in pest and disease incidence due to CO_2 fertilization (Muilenburg and Herms 2013)
- Impact on total crop production and postharvest losses caused by the evolution of pests and diseases
- Impact of ozone damage on crop yields (Ainsworth and McGrath 2010; Iglesias et al. 2009)

METHODOLOGIES

Data analyses from the literature reviewed in this appendix draw from downscaled GCMs. The studies use multiple GCMs, simulate between one and five greenhouse gas emissions scenarios, and incorporate crop prediction models. As a result, the conclusions vary depending on the underlying model assumptions.

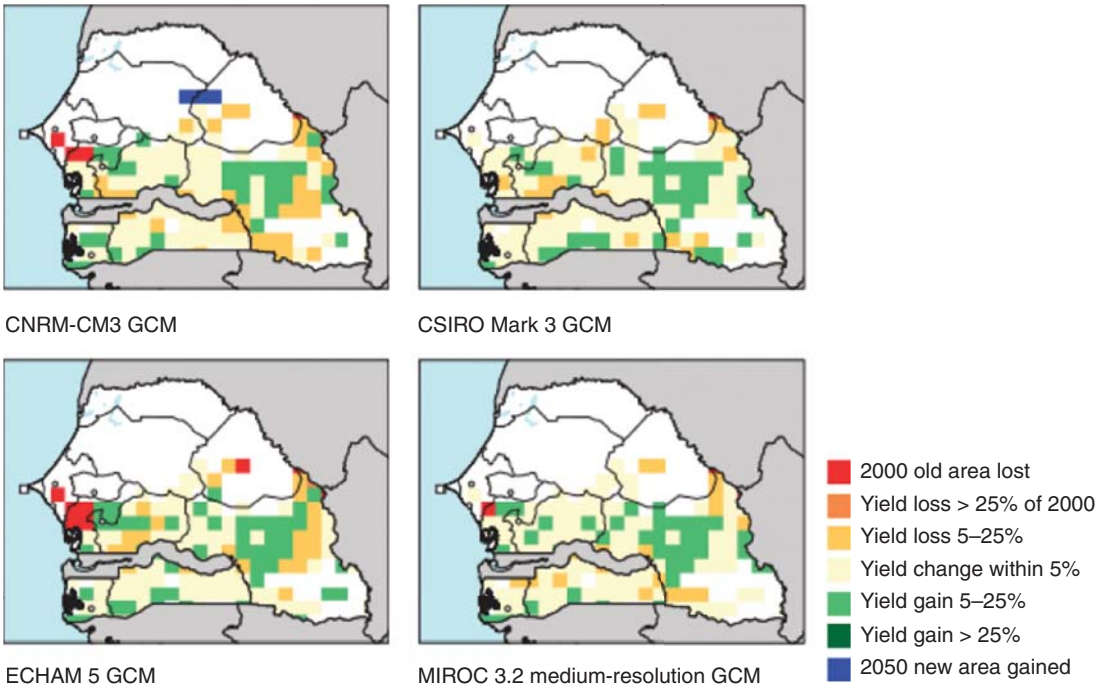
- A country-level International Food Policy Research Institute (IFPRI) study (Khouma et al. 2013, 291–322) compares yield projections for 2050 across four different GCMs (CNRM-CM3, ECHAM 5, CSIRO, and MIROC), using 2000 climate data as the baseline. Each model is simulated with the IPCC A1B emissions scenario, which assumes fast economic growth, a midcentury global population peak, new and efficient technologies, and a mix of fossil and nonfossil energy sources.
- AgMIP (Hathie et al. 2012) projected future crop yields using two crop simulation models calibrated with household survey data and future climate data under five GCMs (CCSM4, GFDL-ESM2M, Had GEM2-ES, MIROC5, and MPI-ESM-MR). The study simulated the effects of climate change with and without adaptation on crop yields using multiyear baseline (1980–2009) and future (2040–69) climate projections. The analysis was limited to Nioro du Rip, a district in southeastern Senegal.
- A multicountry study published in *Environmental Research Letters* (Sultan et al. 2013) projected future crop yields in Senegal based on several climate models from CMIP3 (the World Climate Research Programme's Coupled Model Intercomparison Project), three IPCC emissions scenarios (A2, A1B, and B1), and the crop model SARRA-H v.32. The analysis incorporated multiple climate datasets for the 1961–90 baseline period and simulated the effects of climate change on crop yields through 2100.

CROP PROJECTIONS

MAIZE

Maize is grown in most parts of the country, except in the Sahel and other very dry regions (figure A.1). The most important areas of production areas are located in the

FIGURE A.1. RAIN-FED MAIZE YIELD CHANGE UNDER FOUR CLIMATE MODELS, 2010–50 (IPCC A1B SCENARIO)



Source: Khouma et al. 2013, 311.

southern Groundnut Basin and the Casamance region. Maize is also grown under irrigation in the Senegal River Basin in the north, with higher yields (about 2 tons per hectare) than rain-fed maize (about 1 metric ton per hectare) (Khouma et al. 2013). After rice and wheat, maize is the most-consumed grain in the country, accounting for approximately 10 percent of the food supply (FAOSTAT 2009).

According to the IFPRI study, all models predict that some areas of Senegal will experience maize yield gains of between 5 and 25 percent. The models display considerable agreement on the *location* of the yield increases, but disagree on the *magnitude*. All models also predict that some areas will experience yield losses in places where maize currently grows. The CNRM and ECHAM models predict a larger decline in maize yields than do the CSIRO and MIROC models. The ECHAM model also predicts a greater loss in total harvested area than do the CSIRO and MIROC models. The IFPRI study concludes that maize will be less negatively affected by the impacts of climate change compared with millet and groundnuts.

The AgMIP study, which was limited to a single district in southeastern Senegal, concluded that farmers would experience declines in crop yields, net farm revenue, and per capita income. The simulated models estimated greater economic losses for maize-based farms compared with nonmaize farms.

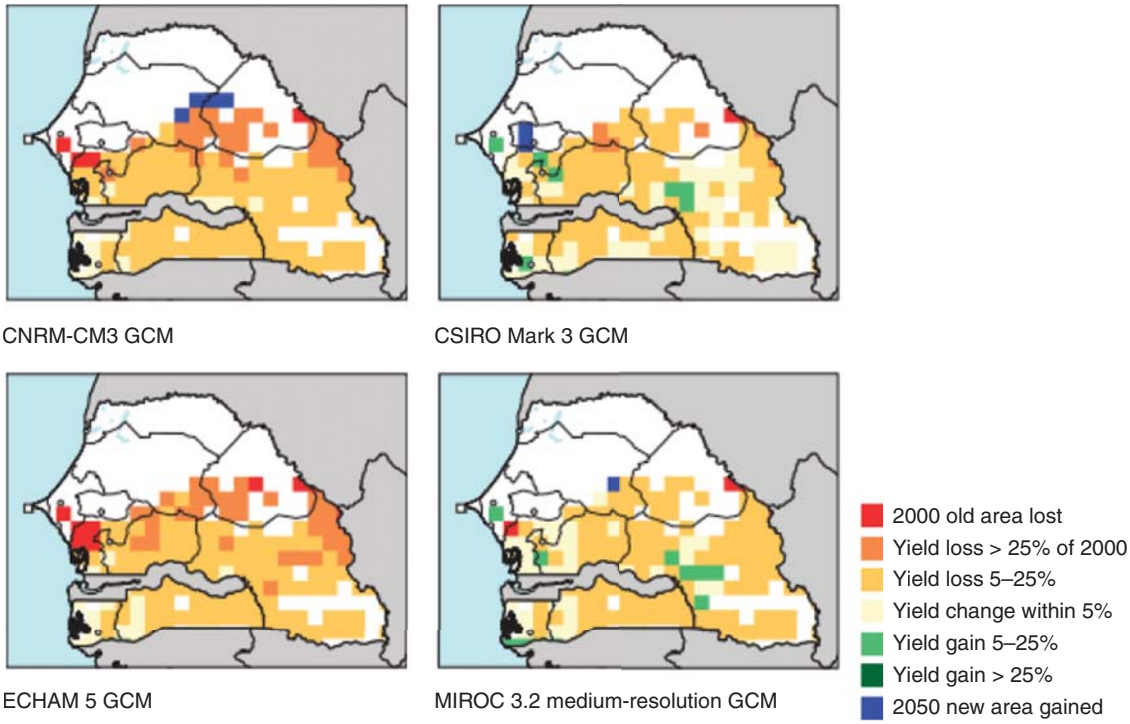
GROUNDNUTS

Groundnuts are the most widely grown crop in Senegal, ranking first in terms of area harvested and second in terms of production volume (figure A.2). Groundnut oil is the country's top agricultural export and an important component of the domestic food supply. Typically, groundnuts are intercropped with millet.

All of the models in the IFPRI study predict a general 5 to 25 percent decline in groundnut yields. Model predictions diverge at the northern edge of the Groundnut Basin: Two of the four models predict yield losses of more than 25 percent in this area. Two of the models predict small areas of yield gains closer to the coast and in the southeast.

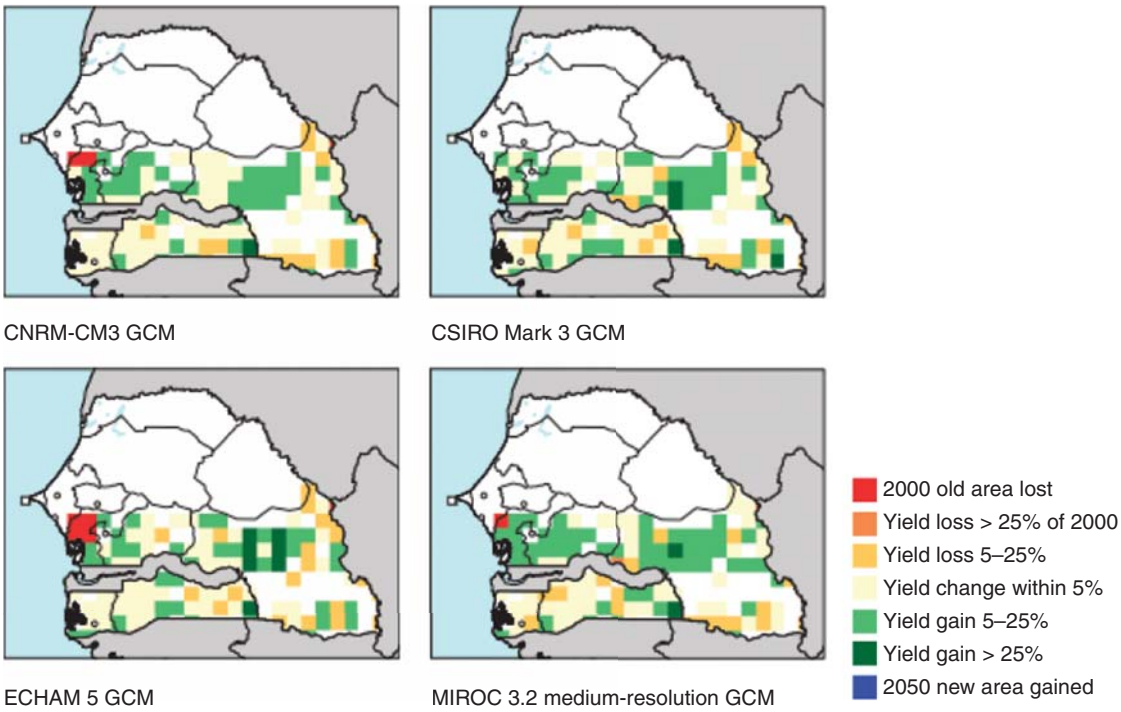
All of the model simulations in the AgMIP analysis predict lower groundnut yields in Nioro district in the 2040–69 period compared with the baseline period.

FIGURE A.2. RAIN-FED GROUNDNUTS YIELD CHANGE UNDER FOUR CLIMATE MODELS, 2010–50 (IPCC A1B SCENARIO)



Source: Khouma et al. 2013, 310.

FIGURE A.3. RAIN-FED RICE YIELD CHANGE UNDER FOUR CLIMATE MODELS, 2010–50 (IPCC A1B SCENARIO)



Source: Khouma et al. 2013, 313.

RICE

Rice is the most widely consumed food in Senegal, accounting for approximately 29 percent of the food supply (FAOSTAT 2009). Between 2001 and 2005, 80 percent of domestic rice consumption depended on imports. Since 2005, domestic rice production has more than doubled, but the country still relies heavily on imports.[9] Rice accounts for approximately 4 percent of the total area harvested in Senegal, behind millet, groundnuts, sorghum, and maize. Rain-fed rice is grown in most areas in the southern half of the country, and irrigated rice is grown in the Senegal River Basin.

According to the IFPRI study, predicted yield increases for rain-fed rice are similar to those for maize, but relatively greater in magnitude, with larger areas of yield gains between 5 and 25 percent (figure A.3). Overall, rice yields are expected to be less negatively affected than groundnuts.

[9] OECD, 2008.

MILLET

After groundnuts, millet is the most widely grown crop in Senegal, accounting for approximately 7 percent of the food supply (FAOSTAT 2009). Millet's contribution to food security is especially important in the Sahel region, where it the most widely consumed and widely cultivated crop.

A study published in *Environmental Research Letters* concluded that millet yields in Senegal would be negatively affected by climate change (Sultan et al. 2013). Out of 35 scenarios, 31 showed a negative impact on millet yields, with yield up to 41 percent. Yield reductions were predicted to be greater in the Sudanian region (southern Senegal), compared with the Sahelian region. According to the multicountry study, traditional cultivars were more resilient than modern high-yielding varieties. However, owing to the large difference in mean yields, modern varieties would still outperform traditional ones (under optimal fertility conditions), even if they are more affected by climate change.

The AgMIP study in Nioro district also concluded that millet yields would be negatively affected by climate change. All model simulations predicted a decrease in future yields compared with the baseline period.

CONCLUSION

Uncertainties surrounding the degree of temperature increases and the direction of change in precipitation levels make it difficult to determine the precise impact of future climate change on crop yields. Predictions of crop yields vary depending on the underlying assumptions, and most models do not account for the way in which the changing incidence of pests and diseases will affect farm productivity. Despite these uncertainties, most studies agree that Senegal's agricultural sector is highly vulnerable to the effects of climate change, and that the overall impacts of climate change will be detrimental to national food security. Absent climate adaptation measures, the effects of climate change can be expected to exacerbate the impact of risk events on farm productivity and food security.

APPENDIX B
SENEGAL VULNERABILITY ANALYSIS

INTRODUCTION

Agricultural shocks are one important factor driving chronic poverty and food insecurity in Senegal. Shocks affect household well-being in a variety of ways, by limiting food availability, weakening food access, and negatively affecting monetary well-being through the depletion of productive assets. Chronically vulnerable groups with high exposure to hazards experience a disproportionate impact from adverse events and lack coping mechanisms available to other groups. In this context, vulnerability is a useful lens through which to examine agricultural shocks because it allows policy makers to determine which groups are most affected and to target risk management solutions accordingly.

GENERAL TRENDS

Rural households are more likely to be poor and food insecure than are urban households in Senegal. In rural districts, 15.1 percent of households are severely or moderately food insecure, compared with 8.6 percent in urban districts. Malnutrition, a direct cause of food insecurity, is significantly higher in rural areas: almost 20 percent of rural children under age five are stunted, compared with 9 percent of children in urban zones. Important sources of vulnerability in the rural environment include (1) poor access to markets, (2) low levels of educational attainment and poor quality education, and (3) lack of diversity in income opportunities. All three factors increase the vulnerability of households to food insecurity and affect rural communities more acutely than urban ones.

TABLE B.1. PREVALENCE OF FOOD INSECURITY BY DISTRICT

District	Severe Food Insecurity (%)	Moderate Food Insecurity (%)
Dakar	<1	4.8
Diourbel	<1	1.9
Mattam	1.5	11.1
Fatick	1.7	3.5
Bounkiling	1.9	11.1
Goudiry	2.2	14.4
Saint-Louis	2.3	10.7
Tambacounda	2.5	15.9
Louga	2.6	7.9
Koumpentoum	2.6	17.8
Bakel	3	9
Kaolack	3.2	23.9
Thiès	3.2	12.6
Goudomp	4.3	18.8
Kanel	4.6	14.1
Kaffrine	4.8	12.1
Salémata	5.2	21.9
Kédougou	5.8	22.7
Vélingara	5.9	16.5
Médina Y.F	6.4	18.7
Saraya	7.9	28.4
Ranérou	9	8.8
Kolda	9.2	23.4
Sédhiou	9.6	10.9
Bignona	19.7	22.7
Ziguinchor	20	30.4
Oussouye	35	23.7
Rural Districts	**3.7**	**11.4**
Guédiawaye	0.6	5.5
Kédougou	1.9	5.8
Tambacounda	2.3	5.3
Oussouye/Bignona	12.4	21.3
Urban Districts	**2**	**6.6**

Source: WFP 2011.

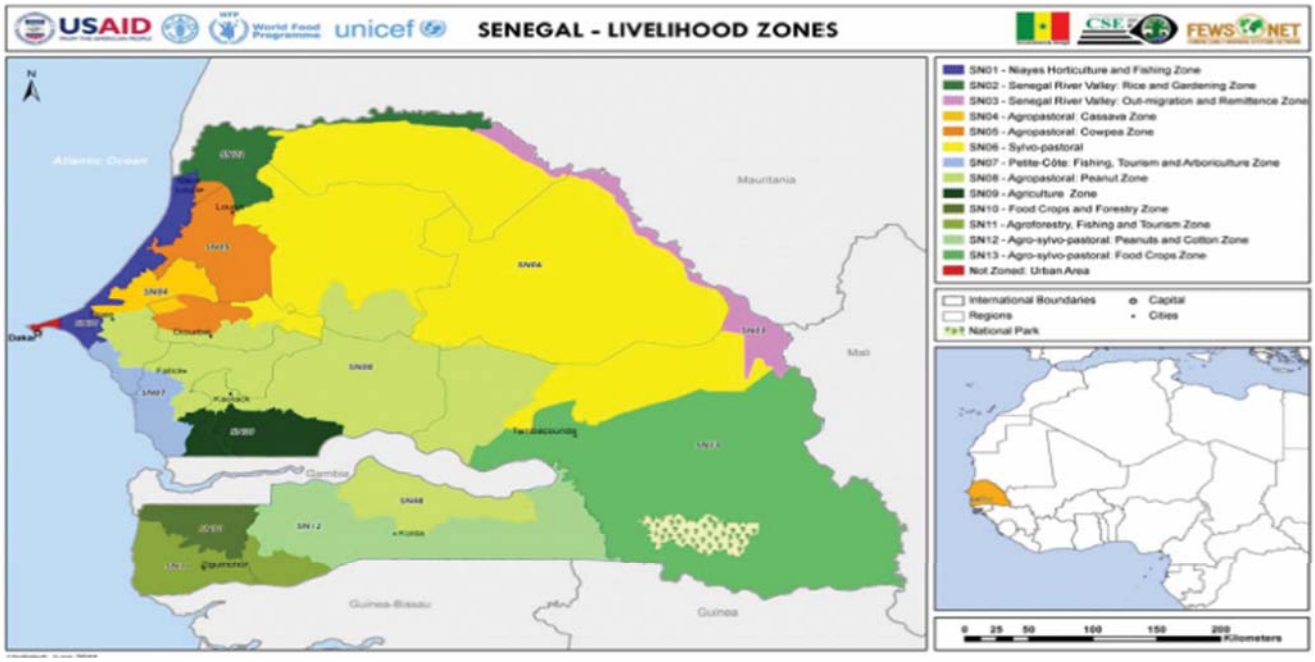
Location is a key determinant of poverty and food security status for Senegalese households. In fact, national averages of food security and poverty mask stark regional differences. The prevalence of severe food insecurity ranges from less than 1 percent in Dakar and Diourbel to 35 percent in Oussouye (see table B.1).

Food price shocks are by far the most important source of vulnerability for both rural and urban households. More than 34 percent of rural households and 29 percent of urban households reported experiencing a spike in food prices between April 2009 and April 2010. Households experience food price volatility more frequently than any other risk event.

AGRO-CLIMATIC CONDITIONS, LIVELIHOODS, AND VULNERABILITY

In rural areas, the prevailing agro-climatic conditions, particularly rainfall and water resources, are strong predictors of livelihood activities, which in turn influence household food consumption and vulnerability (figure B.1). In areas rich in water resources, producers are more likely to grow cash crops, employ farm laborers, sell market garden products, and engage in fisheries. In the Sahel region where rainfall is highly variable, communities rely heavily on pastoralist activities and drought-tolerant food crop production. Because three-quarters of rural Senegalese households do not produce enough food to meet their minimum food requirements, diversification of revenue sources and access to markets are important determinants of both poverty and food security. Households that lack multiple sources of income and market opportunities are more vulnerable to a range of production and market risk events. These types of households exist in all livelihood zones, but are most prevalent in the agro-pastoral and sylvo-pastoral zones. Several underlying factors increase the vulnerability of pastoral and agro-pastoralist communities, including land fragmentation, population growth, low literacy and education provision, and poor infrastructure. These chronic weaknesses undermine the capacity of communities to respond to shocks. In turn, the increasing frequency and simultaneous occurrence of multiple shocks

FIGURE B.1. SENEGAL LIVELIHOOD ZONE MAP



Source: FEWSNET http://www.fews.net/west-africa/senegal/remote-monitoring-report/may-2014.

erode the effectiveness of traditional coping mechanisms, creating a vicious cycle of crisis and underdevelopment.

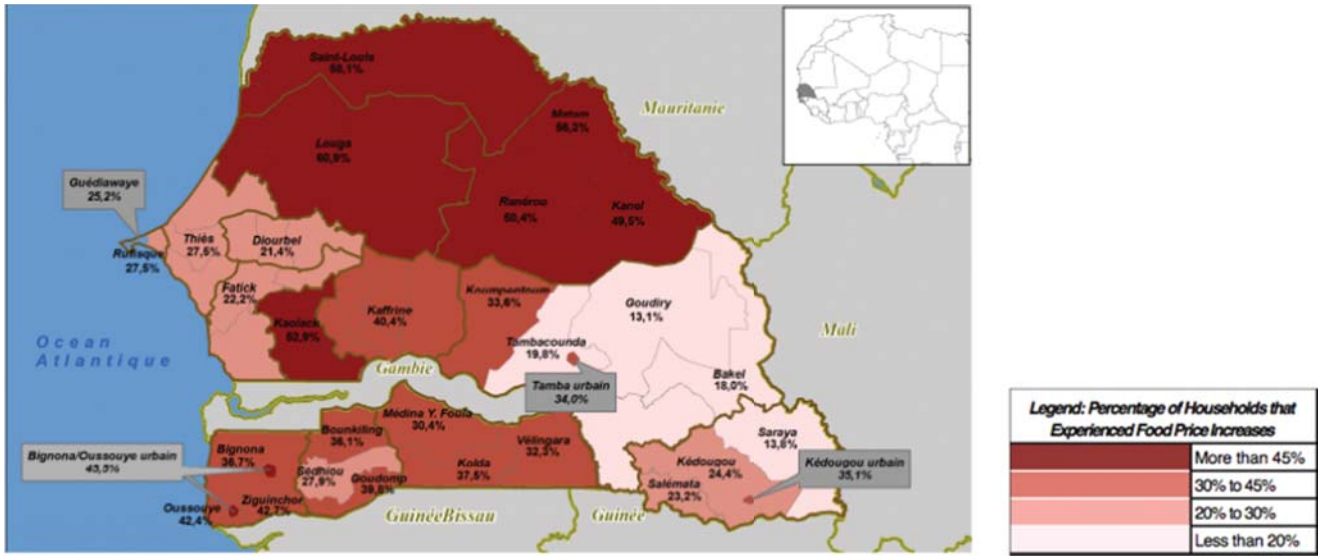
LIVESTOCK OWNERSHIP AND FOOD SECURITY

Although pastoralists and agro-pastoralist zones have above-average rates of food insecurity, livestock ownership is actually positively correlated with food security. In rural areas of Senegal, food-secure households have an average of 8.4 tropical livestock units (TLU), compared with 5.1 TLU for food-insecure households. The ability to sell productive assets during the annual lean season to obtain food and basic necessities is an important coping strategy for agricultural households. Households with large herd sizes are better equipped to employ this strategy, without compromising their future income, than households with only a few animals or stockless households.

FOOD PRICE VOLATILITY AND VULNERABILITY

As mentioned previously, the vast majority of both urban and rural households purchase at least some of their food on the market, especially during the annual lean season when prices peak. Dependence on the market is compounded by Senegal's reliance on food imports and exposure to international price fluctuations, which directly affect household purchasing power. As a result, Senegalese households are extremely vulnerable to food price shocks. Figure B.2 depicts the geographic distribution of food price shocks, measured by the percentage of households that reported experiencing one or more food price increases in the previous 12 months. Households in the northern Sahel region were more likely to experience food price shocks than any other part of the country (except the Kaolack region, where households were similarly affected).

FIGURE B.2. FOOD PRICE SHOCKS BY DISTRICT



Source: WFP 2011.

TABLE B.2. VULNERABLE GROUPS

Pastoralists and agro-pastoralists	• 37% of households that depend on livestock belong at the bottom income quintile. More than 60% are considered poor or very poor. • Illiteracy rate is 59% among head-of-households (HH). Households with an illiterate HH are more likely to be food insecure than are those with similar characteristics and a literate HH. • Low savings rate (between 11% and 13%).
Unskilled wage laborers	• 29% of households that depend on wage labor belong to the bottom income quintile. More than 60% are considered poor or very poor. • Low savings rate (between 11% and 13%). • Second-lowest monthly expenditure (US$1.13 per person per day).
Food crop farmers	• 28% of these households belong to the bottom income quintile. More than 50% are considered poor or very poor.
Cash crop farmers	• Similar to food crop farmers, 29% of these households belong to the bottom income quintile. More than 50% are considered poor or very poor.
Households that rely primarily on forest resources	• More than 50% of these households belong to the bottom income quintile. More than 75% are considered poor or very poor. • Low savings rate (between 11% and 13%). • Lower monthly expenditure than any other livelihood group (US$0.94/person/day). • 25% of households do not eat three meals a day.

Source: WFP 2011.

APPENDIX C
AGRICULTURAL INSURANCE IN SENEGAL

Agriculture is important for Senegal. It contributes 20 percent to GDP and provides employment to 60 percent of its workforce. It is key to food security and to protect the country against the increasing fluctuations of international food prices, which saw rice prices triple in 2007–08.

The increase of agriculture productivity is a paramount objective of the government of Senegal. The Programme de Relance et d'Accélération de la Cadence de l'Agriculture au Sénégal aims at implementing the objectives of the Plan Senegal Emergent in the agriculture sector and focuses on four strategic crops: rice, onions, groundnuts, and off-season fruits and vegetables. The underlying goals that explain the selection of these crops are: (1) coverage of the whole of Senegal with these products; (2) gradual suppression of food dependence (rice and onions); (3) development of exports (off-season fruits and vegetables); and (4) jobs creation and additional income generation.

Agriculture is risky in Senegal. Ninety-eight percent of cultivated land is rain fed, and as Senegal belongs to the Sahel, rain is scarce in parts of the country and unreliable across the country, causing damage by excess as well as scarcity. The World Bank's Agriculture Risk Management Team estimates that during 1980–2012, total losses from production risks affecting maize, rice, millet, sorghum, peanuts, and cowpeas alone totaled US$1.38 billion, that is, US$41.7 million per year. A detailed report was shared with the government of Senegal in the second half of 2014; its findings have informed the work of the AIDP and this report.

World Bank analysis using the Modèle d'Analyse des Risques de Cultures du Sénégal modeled an average annual crop loss cost of 10 percent of national crop value and indicates a 1 in 100 year loss of 44 percent of the national average crop value. The 2002–03 drought cost an estimated 35 percent of national crop production, almost US$50 million. Annual groundnut production decreased by 70 percent, likewise the average cash flow to groundnut farmers. The 2004–05 locust infestation reduced millet yields by 23 percent and sorghum yields by 14 percent. The livestock sector is also

affected: the 2011 drought required government to spend CFA 4 billion on 21,000 tons of forage to control livestock mortality.

Climate change is likely to aggravate rural households' exposure to risk. Mean annual temperature has increased by almost 1°C between 1960 and 2006 and may increase by up to 3°C by midcentury. Variability of rainfall patterns has also increased, causing both droughts and floods. The model of the World Food Programme and the Agence Nationale de l'Aviation Civile et de la Météorologie estimates that climate variability explains half of agriculture yield variations in Senegal (ANACIM 2012). Repeated droughts, along with population growth and agriculture expansion, have already led to severe environmental degradation in wide parts of the country.

Agricultural risk limits access to finance, and that restrains agriculture productivity. To increase productivity, crop and livestock producers have to invest, and in most cases they depend on credit to do that. The supply of credit usually does not meet their needs, and although logistical challenges are one reason for this mismatch, risk is another. In Senegal, the 1988–91 banking crisis shows how drought precipitated the closure of seven banks (Caprio and Klingebiel 1996).

One common risk management approach of farmers in Senegal as elsewhere is diversification of income sources. Forty-one percent of rural households have two main sources of income and 44 percent depend on three or more sources. In contrast, 43 percent of urban households depend on one livelihood activity. The agriculture production of rural households is itself characterized by diversification, as different crops are planted on the often-fragmented small plots. This is a very sensible approach to addressing risk in the absence of other instruments to manage risk. But it limits their productive capacity as they forgo higher profits in riskier activities.

Insurance has been recognized as one important instrument to address risk by pooling and transferring it. Risk transfer complements risk mitigation and risk coping as the third fundamental pillar to address agriculture risk. Insurance is one of the oldest and best-developed instruments for risk transfer; it has contributed to prosperity of developed countries around the world, and is increasingly reducing vulnerability and protecting productive investment also in developing countries. The formalization of organized solidarity for the redistribution of money between individuals and in time under the concept of insurance has been refined for centuries. The mathematical law of large numbers explains how the outcome of a collection of comparable units (such as agriculture hectares or livestock units) exposed to risk is more predictable than the outcome of each one of the units, thus moving from gambling to the statistical management of risk that allows commercial companies to sustainably offer insurance in exchange for a commensurate premium. In this way, insurance transforms future uncertainty into predictability, for government budgets as well as for households.

Although insurance is a mature and well-developed instrument, agriculture insurance is one of the later lines to emerge, and it has not been available to small-scale farmers until very recently. The principal obstacle that has excluded small-scale farmers from agriculture insurance is the cost of claims assessment, which traditionally requires farm visits of highly specialized experts but is not viable for small farmers. Fortunately, this obstacle is being overcome with the spread of index-based agriculture insurance during the past 15 years.

Agriculture insurance serves two main purposes. On the one hand, it reduces vulnerability, in that it compensates producers for the economic losses suffered from insured events, thus preventing them from falling into poverty and/or using suboptimal strategies to cope with the losses, such as reducing food consumption, selling productive assets, or taking children out of school. On the other hand, it increases productivity through increased investment by securing credit in case of loan default due to insurable events; this encourages lenders to offer credit to the otherwise risky client group of farmers and herders. Subsistence farming may work without access to credit, but the market oriented productivity growth that Senegal wants from its agriculture sector will require considerable credit. This is unlikely to become available without insurance solutions that remove the agriculture risks that lenders are not prepared and equipped to bear themselves.

Although insurance is a powerful ex ante instrument to address risk before it materializes in the form of adverse events, it coexists with ex post mechanisms, typically government or donor handouts after the event. Setting up disaster funds with more or less elaborated rules of funding and disbursing to target populations in case of calamities is more straightforward than developing insurance solutions in countries where the corresponding insurance markets are not well developed. Such funds give governments control and flexibility, may attract donor funding, and can serve other political objectives. If not based on clear and generally known rules, however, they keep the target beneficiaries in uncertainty about what to expect, limiting investment on the one hand and individual initiative to mitigate risk on the other. And if not based on solid governance, such funds may not be available as needed.

Agriculture risk is a continuum, and different instruments are best suited to address different severities. Just as instruments for risk mitigation, risk transfer, and risk coping each have their role to address different degrees of severity, different instruments for risk transfer such as contingent budgets or funds, contingent credits, and insurance solutions can be combined for best results.

The government of Senegal has implemented a number of measures aimed at reducing vulnerability of agriculture and livestock producers and at increasing their access to finance. The Fonds de Securisation, Fonds d'Appui à la Stabulation, and Fonds de Garantie des Investissements Prioritaires all aim to promote lending to farmers and herders and include guarantees that operate like insurance by compensating lenders for loan defaults. The Opération de Sauvegarde du Bétail and the African Risk Capacity are insurance or insurance-like mechanisms that reduce the vulnerability of Senegal's herders.

Acknowledging the importance of insurance, the government of Senegal created the Compagnie Nationale d'Assurances Agricole du Sénégal (CNAAS) in 2008 together with the country's insurance industry. Before then, agriculture insurance was limited to farm equipment and had little outreach. To crowd in the private sector and let the insurance industry profit from lessons learned on products and processes, Senegal's private sector insurance companies were invited to jointly own the majority of the CNAAS. This has resulted in a well-run and equipped national champion of agriculture insurance whose development has benefited from ongoing government support.

International research shows that agriculture insurance programs conducted by either the public sector or the private sector alone struggle considerably to succeed; moreover, public-private partnerships tend to be a necessary condition for successful scale of agriculture insurance. On a global basis, only 7 percent of agricultural insurance transaction volume is purely private. Market and regulatory impediments are often invoked to justify public intervention; they include the systemic nature of agriculture risk, information asymmetries, and the low motivation of any private sector company to invest in the public good of the Agricultural Risk Market Infrastructure necessary for functioning agriculture insurance. Private insurance providers operated in 54 percent of the 65 countries surveyed by the World Bank in 2008, and public-private partnerships were implemented in 37 percent of them (Mahul and Stutley 2010).

CNAAS has experienced good growth and offers a wide range of products for farmers and herders, but will need substantial additional growth and product evolution to serve significant proportions of rural households, reduce their vulnerability, and secure their investments in increased productivity. In March 2014, the CNAAS estimated that it had insured approximately 5,000 producers with about 8,000 hectares in 2013, and 1,500 livestock producers with about 200,000 animals (three-quarters of them chickens). This is a substantial growth since the company's first year of operation, and healthy growth is projected going forward. But the outreach to wider rural populations is still limited, and considerably more scale will be required for the CNAAS to noticeably reduce Senegalese vulnerability to shocks and secure the required large amounts of credit. With the current level of development of agricultural insurance, Senegal's small and marginal crop and livestock producers are still too reliant on ex post disaster relief interventions by the government and donor partners.

TABLE C.1. INSURANCE PREMIUM COMPONENTS

Premium Component	Function	Potential Reduction
Actuarial premium	Quantifies the statistically expected payments	Focus on infrequent severe events
Loading for deviations	Honor payment liabilities in years when claims exceed premiums	Larger pool size to reduce statistical variance
Loading for reinsurance	Sharing risk with larger pools to protect insurer against statistical outliers Reduce capital requirements Benefit from specialized expertise of reinsurers	Larger pool size to reduce statistical variance and the need for reinsurance, reduce statistical variance of cessions to reinsurers, and offer more attractive business proposition to reinsurers Government financing of reinsurance layers
Loading for amortization of up-front cost	Recover initial investment in product and process development, IT, and so on	Donor funding of start-up expenses
Loading for data cost	Fund payment to providers of recurrent data needs	Public good data access
Other administration expense loading	Fund ongoing variable operation cost	Outsource administrative tasks to lower cost providers
Distribution expense loading	Fund ongoing distribution cost	Partner with lower cost distribution channels, such as government rural outreach infrastructure
Profit margin	Justify the effort and build reserves	Increase business volume and outlook for future market growth

Agriculture insurance is expensive. Depending on circumstances, it can reach 10 percent or more of the expected payout amounts, compared with less that 1 percent for life insurance, for example. This is not necessarily an obstacle for prosperous producers (which are few) but usually is a challenge for low-income farmers and herders (which constitute the majority), and contributes to explain the slow growth of agriculture insurance in most developing countries.

The level of the insurance premium—and hence the affordability of insurance—is driven by various factors, and each one of them can be addressed to make premium more affordable.

The main components of any insurance premium are contained in table C.1.

The various components of an insurance premium correspond to various roles and interventions that the public and the private sector can assume. Distribution and servicing of insurance to rural populations, for example, is costly, and initial volumes of agriculture and livestock insurance may not look sufficient to justify the up-front investment in developing the necessary structures. Partnering with organizations that already have that infrastructure in place is promising; they may come from the private sector—such as rural financial institutions—as well as from the public sector—such as Regional Office for Rural Development (DRDR), Departmental Office for Rural Development (SDDR), Service Regional de l'élevage (SREL) Regional Office for Livestock Service, Service Départemental de l'élevage (SDEL) Departmental Office for Livestock Services, and Agence Nationale du Conseil Agricole et Rural.

Ongoing government support such as premium subsidies and tax exemptions are powerful stimulants but leave room for further strengthening of agriculture insurance in Senegal. Examples of possible additional support include the following:

1. Reduction of administration and distribution expenses by access to government rural infrastructure and staff for insurance-related tasks such as veterinary services or awareness creation
2. Reduction of statistical variance, reinsurance cost, and per-policy administration and distribution cost through growth of the insurance pool by mandatory inclusion of insurance in rural development projects related to agriculture, livestock, and fishing

3. Reduction of statistical variance, reinsurance cost, and per-policy administration and distribution cost through growth of the insurance pool by mandatory inclusion of insurance in government-supported agriculture lending
4. Reduction of up-front cost and administration expenses through free access to meteorological and crop yield data necessary to design, price, and service index insurance
5. Reduction of administration expenses through the establishment of and free access to a livestock registry
6. Reduction of administration and distribution expenses if cross-selling of other lines of insurance to rural populations is allowed in addition to agriculture insurance

Governments often provide support for the financing of risk through direct premium subsidies, but there are risks with this approach. Governments hope that subsidizing premiums will incentivize insurers to enter the market and will increase the take-up of insurance products and therefore outreach. However, experience documented from elsewhere points to potential risks with this approach, including the following:

1. Sustainability: Direct premium subsidy can become quite costly and is subject to changing political priorities.
2. Market distortion: Premium subsidy can lead to market distortion.
3. Poor incentives: Premium subsidy can motivate undesired behavior by insurers and reinsurers (leading to overpricing) and insured policyholders (by crowding out alternative risk mitigation strategies).
4. Poor targeting: It is difficult to target subsidies to those who need it.
5. Effects of withdrawal: Withdrawal of subsidy may to lead to an increase in price, which can severely affect future take-up—particularly if the subsidy is withdrawn too rapidly—and thus reverse the benefits intended by the subsidy.

In addition to the government-led interventions aiming to reduce farmer and herder vulnerability and increase access to finance, Senegal is characterized by a dynamic landscape of donor-driven agriculture insurance initiatives. CNAAS is testing novel approaches to agriculture insurance in pilots with partners including the Global Index Insurance Facility, the World Food Programme, and USAID, and another program funded by the West African Development Bank is expected to start soon. A comprehensive government strategy on agriculture insurance should take into consideration the lessons learned and expected outcomes of these projects, and be informed of the gaps not yet covered by any of the existing government and nongovernment insurance and noninsurance interventions, to avoid duplications.

Any agriculture insurance strategy should also take into consideration existing social protection mechanisms and objectives to explore synergies. Subsidized agriculture insurance premiums amount to self-targeted transfer payments. They are aimed at reducing vulnerabilities of specific target groups, but only farmers and herders who buy insurance benefit from them; hence these transfers often benefit the rich more than they do the poor. Links between insurance and social protection mechanisms are varied and can be complex. Increasingly, the concept of payments triggered by readily available indexes that correlate with hardship is transferred from agriculture and disaster index insurance to social safety nets, where benefits are increased or provided to larger populations based on suitable indexes that allow such dynamic response to be very fast and well targeted. If based on insurance quality indexes, such increases in government payments can be transferred to international reinsurance markets, reducing budget uncertainty.

APPENDIX D
CROP YIELD LOSS ANALYSES

FIGURE D.1. GROUNDNUTS, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1980	333,101	–117.2
1983	–339,662	–$119.5
1984	–197,985	–$69.6
1992	–204,762	–$72.0
1996	–113,385	–39.9
1997	–107,586	–37.8
2002	–420,376	–147.8
2006	–41,281	–14.5
2007	–182,587	–64.2
2011	–211,477	–74.4
Total:	**–2,152,202**	**–757.0**

Source: DAPS.

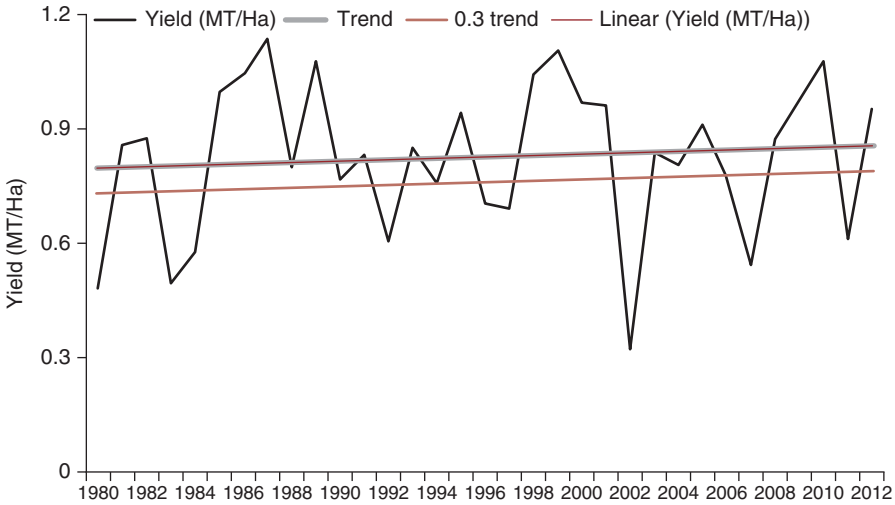


FIGURE D.2. COTTON, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1980	–2,443	–0.400
1982	–1,988	–0.492
1996	–2,516	–0.444
1997	–3,250	–0.563
1998	–17,301	–2.45
1999	–1,766	–0.204
2002	–1,715	–0.179
2009	–1,913	–0.272
2011	–1,350	–0.441
2012	–1,347	–0.261
Total:	**–35,589**	**–5.7**

Source: FAOSTAT.

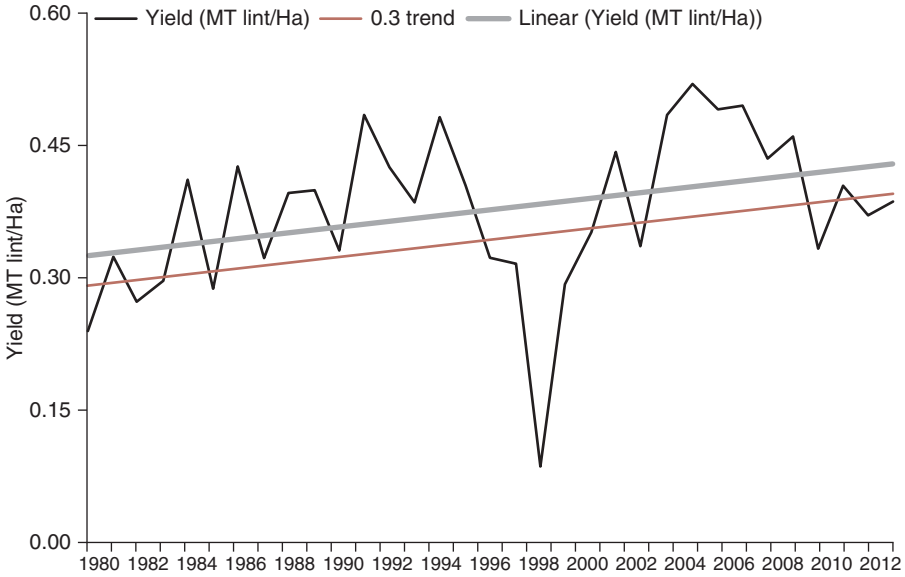


FIGURE D.3. MAIZE, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1980	−16,677	−5.3
1994	−25,517	−8.0
1995	−18,238	−5.7
1996	−21,469	−6.7
1997	−21,723	−6.8
1998	−27,694	−8.7
1999	−29,902	−9.4
2000	−19,385	−6.1
2001	−15,899	−5.0
2002	−74,229	−23.4
2007	−63,302	−19.9
2011	−54,419	−17.1
Total:	**−388,454**	**−122.3**

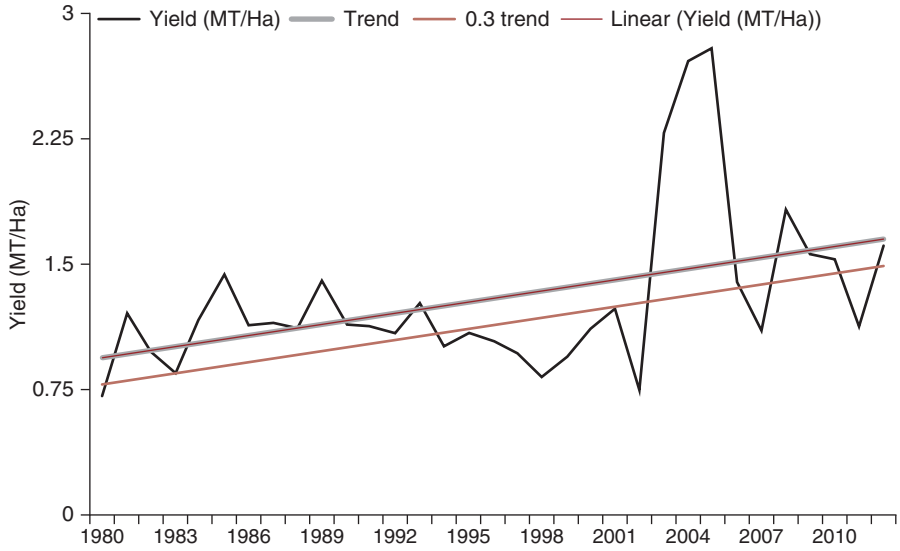


FIGURE D. 4. RICE, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1980	−34,165	−10.8
1996	−31,944	−10.1
2000	−29,967	−9.5
2001	−33,236	−10.5
2002	−41,616	−13.2
2004	−37,596	−11.9
2006	−69,667	−22.1
2007	−57,233	−18.2
Total:	**−335,423**	**−106.6**

Source: FAOSTAT.

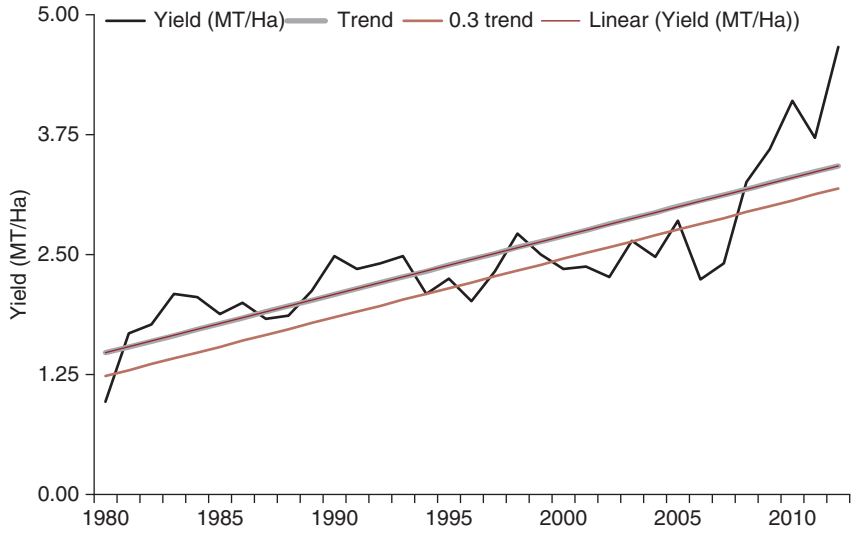


FIGURE D.5. COWPEA, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1982	−5,792	−3.8
1983	−1,414	−0.93
1984	−3,121	−2.0
1990	−3,657	−2.4
1992	−8,761	−5.7
1996	−9,601	−6.3
2002	−31,143	−20.5
2003	−13,282	−8.7
2004	−49,783	−32.7
2006	−9,949	−6.5
Total:	**−136,503**	**−89.7**

Source: DAPS.

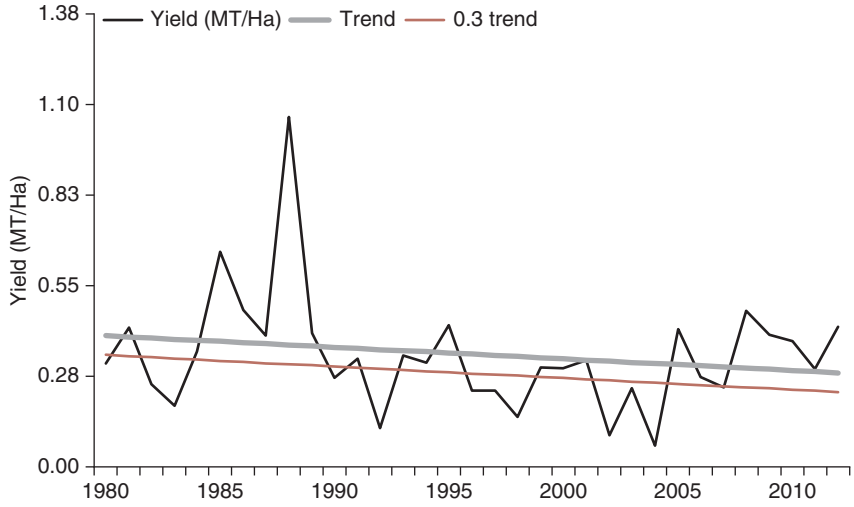


FIGURE D.6. POTATO, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1992	−6,529	−0.947
2000	−4,662	−0.676
2003	−2,523	−0.366
2004	−1,614	−0.234
2005	−1,859	−0.270
2008	−1,942	−0.282
Total:	**19,129**	**−2,774**

Source: DAPS.

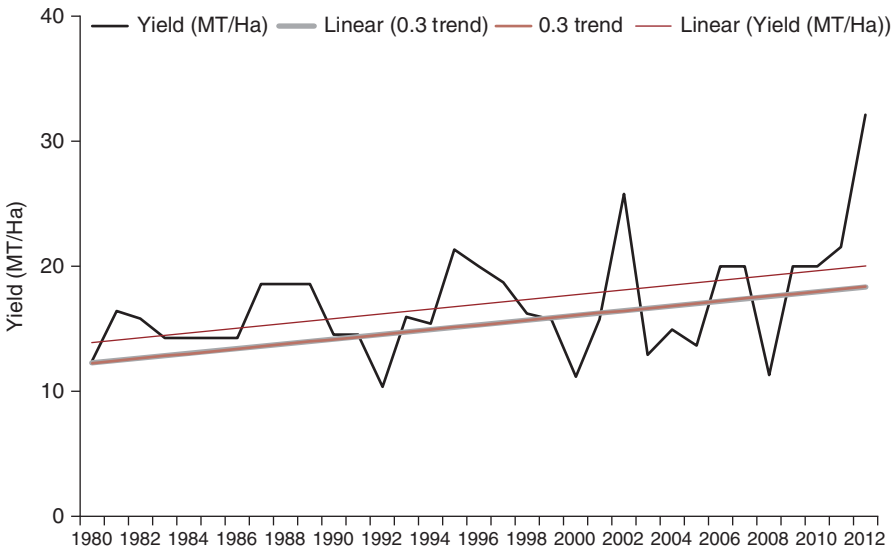


FIGURE D.7. TOMATO, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1994	−12,052	−2.4
1996	−4,984	−1.0
1997	−14,103	−2.8
1998	−17,432	−3.5
1999	−17,737	−3.6
2000	−41,486	−8.4
2001	−32,456	−6.5
2004	−27,109	−5.5
2008	−11,304	−2.3
Total:	**−178,665**	**−36.0**

Source: DAPS.

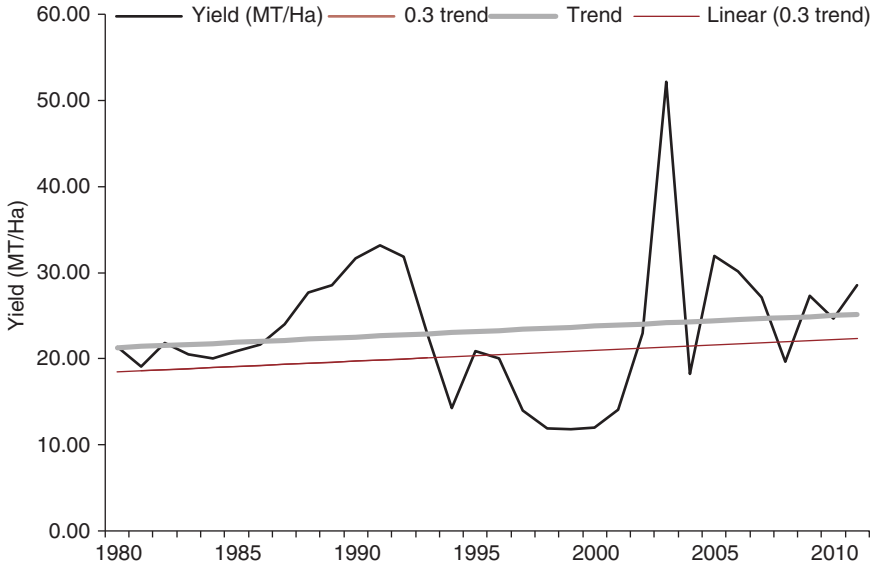


FIGURE D.8. ONION, 1980–2012

Years	Loss (in MT)	Loss (US$, millions)
1991	−5,130	−2.8
1995	−4,039	−2.2
1999	−13,475	−7.4
2000	−25,111	−13.8
2001	−13,575	−7.5
2002	−30,095	−16.5
2003	−11,917	−6.5
2010	−28,524	−15.7
Total:	**−131,867**	**−72.5**

Source: DAPS.

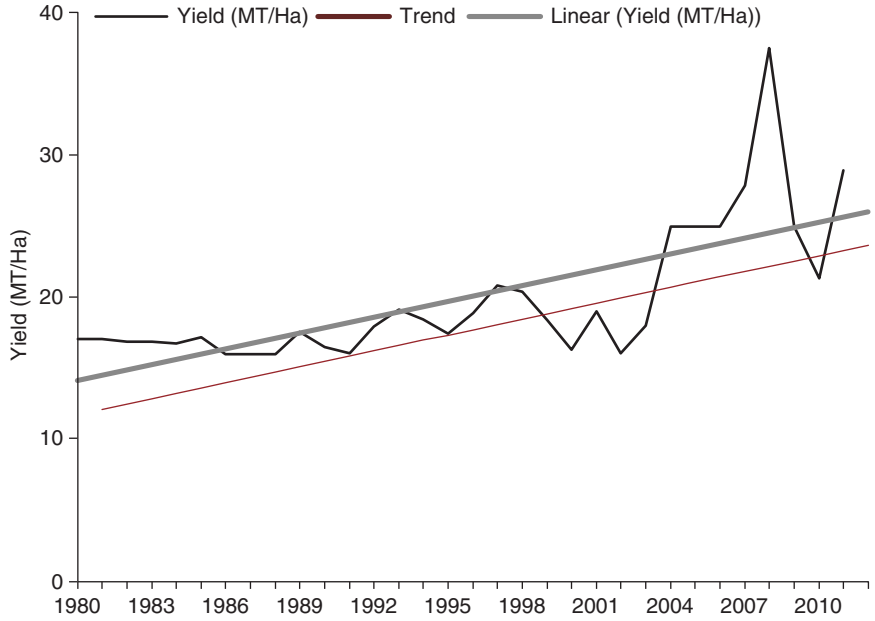


FIGURE D.9. GREEN BEAN, 1989–2012

Years	Loss (in MT)	Loss (US$, millions)
1994	−1,387	−0.71
2000	−1,592	−0.82
2001	−939	−0.48
2002	−1,286	−0.66
2007	−3,846	−2.0
2008	−2,602	−1.3
2009	−4,522	−2.3
Total:	**−16,173**	**−8.33**

Source: DAPS.

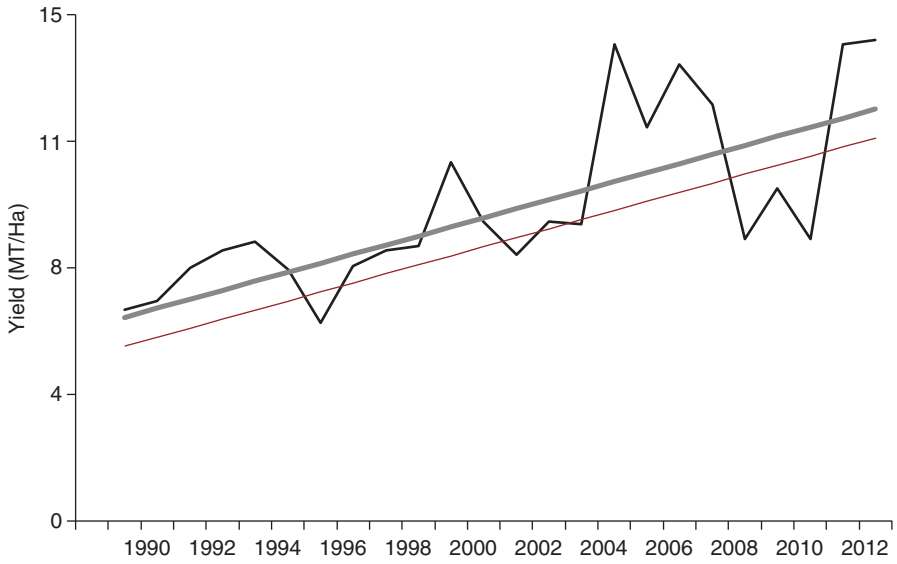
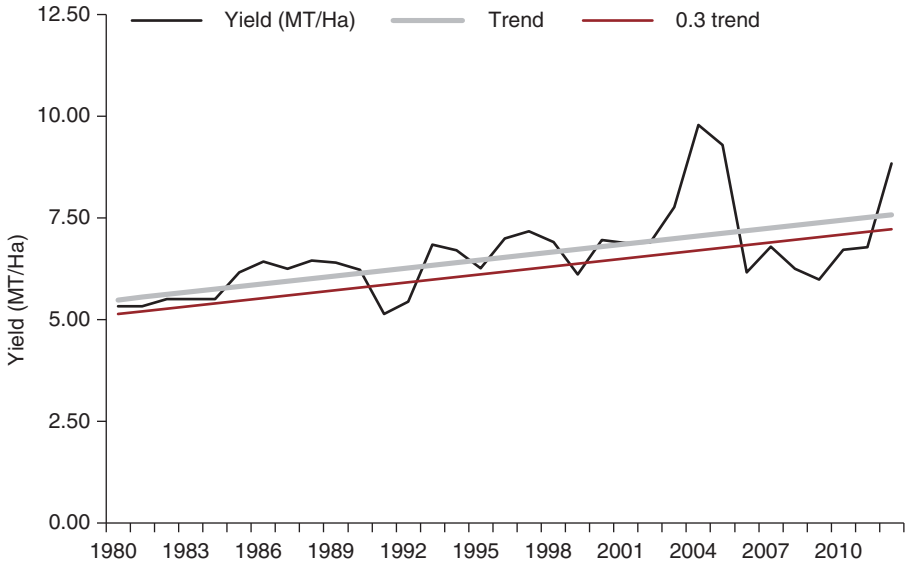


FIGURE D.10. MANGO, 1989–2012

Years	Loss (in MT)	Loss (US$, millions)
1980	−1,990	−0.79
1981	−2,316	−0.92
1983	−1,967	−0.78
1984	−2,292	−0.91
1991	−11,768	−4.68
1992	−9,120	−3.62
1999	−7,297	−2.90
2006	−12,160	−4.83
2007	−4,819	−1.91
2008	−14,947	−5.94
2009	−21,056	−8.37
2010	−8,661	−3.44
2011	−10,041	−4.0
2012	−11,922	−4.7
Total:	**−120,355**	**−47.84**

Source: DAPS.



APPENDIX E
CROP PEST ANALYSIS

TABLE E.1. RICE: PREHARVEST

	Species (common name)	Losses
Devastating pest	*Locusta migratoria* (migratory locust) *Oedaleus senegalensis* (Senegalese grasshopper) *Mythimnauni loreyi* (maize caterpillar) *Mythimnauni puncta* (rice armyworm)	Total
Major pest	*Agrotis segetum* (turnip moth) Dimorphopterus	
Major pest—role in virus and disease transfer	*Orseolia oryzivora* (African rice gall midge) *Cofana spectra* (white leafhopper) *Leptoglossus gonagra* (squash bug) *Trichispase ricea* (rice, hispid)	Up to 15%
Cob borers and stem borers	*Chilo diffusilineus* *Chilo zacconius* *Corcyra cephalonica* (rice meal moth) *Earias insulana* (Egyptian stem borer) *Eldana saccharina* (African sugarcane borer) *Heteronychus licas* (black sugarcane beetle) *Sesamia calamistis* (African pink stem borer) *Spodoptera exempta* (black armyworm) *Spodoptera exigua* (beet armyworm) *Spodoptera littoralis* (cotton leafworm)	
Minor pests	*Atherigona orientalis* (pepper fruit fly) *Gryllotalpa africana* (african mole cricket) *Nezara viridula* (green stink bug) *Pachnoda interrupta* (chafer beetle) *Parapoynx stagnalis* (rice case worm)	

TABLE E.2. RICE: POSTHARVEST

	Species (common name)	Losses
Major postharvest pests	*Rhyzopertha dominica* (lesser grain borer) *Sitophilus zeamais* (greater grain weevil) *Sitotroga cerealella* (grain moth) *Stegobium paniceum* (drugstore beetle) *Tribolium castaneum* (red flour beetle)	Up to 15%
Minor postharvest pests	*Cadra cautella* (driedcurrantmoth) *Liposcelis bostrychophila* (book louse) *Liposcelis entomophila* (grain psocid)	Up to 5%

TABLE E.3. SORGHUM: PREHARVEST

	Species (common name)	Losses
Devastating pest	*Locusta migratoria* (migratory locust) *Oedaleus senegalensis* (Senegalese grasshopper) *Schistocerca gregaria* (desert locust)	Total
Quarantine pest	*Thaumatotibia leucotreta* (false codling moth)	
Major pest	*Atherigona soccata* (shootfly) *Agrotis ipsilon* (black cutworm) *Mythimnauni loreyi* (maize caterpillar) *Stenodiplosis sorghicola* (sorghum midge) *Diabolocatantops axillaris* (devil grasshopper) *Rhinyptia infuscata* *Trichoplusia ni* (cabbage looper)	
Major pest—role in virus and disease transfer	*Aphis spiraecola* (Spirea aphid) *Melanaphis sacchari* (yellow sugarcane aphid) *Rhopalosiphum maidis* (green corn aphid)	
Major pest—cob borers and stem borers	*Eldana saccharina* (African sugarcane borer) *Helicoverpa armigera* (cotton bollworm) *Sesamia calamistis* (African pink stem borer) *Spodoptera exempta* (black armyworm) *Spodoptera littoralis* (cotton leafworm) *Heteronychus licas* (black sugarcane beetle)	
Minor pests	*Anoplocnemis curvipes* (giant coreid bug) *Atherigona orientalis* (pepper fruit fly) *Dimorphopterus* spp. *Nezara viridula* (green stink bug) *Pachnoda interrupta* (chafer beetle)	Less than 2%

TABLE E.4. SORGHUM: POSTHARVEST

	Species (common name)	Losses
Major postharvest pests	*Araecerus fasciculatus* (cocoa weevil) *Cadra cautella* (driedcurrant moth) *Rhyzopertha dominica* (lesser grain borer) *Sitophilus zeamais* (greater grain weevil) *Sitotroga cerealella* (grain moth) *Tribolium castaneum* (red flour beetle)	Up to 30%
Quarantine pest	*Trogoderma granarium* (khapra beetle)	Total—needs to be destroyed
Minor postharvest pests	*Alphitobius laevigatus* (black fungus beetle) *Corcyra cephalonica* (rice meal moth) *Liposcelis bostrychophila* (book louse) *Liposcelis entomophila* (grain psocid)	

TABLE E.5. MILLET: PREHARVEST

	Species (common name)	Losses
Devastating pest	*Locusta migratoria* (migratory locust)	Total
Major pest	*Pachnoda interrupta* (chafer beetle)	Up to 50%
Cob borers and stem borers	*Spodoptera exempta* (black armyworm)	
Minor pest	*Mythimna unipuncta* (rice armyworm)	

TABLE E.6. MILLET: POSTHARVEST

	Species (common name)	Losses
Quarantine pest	*Trogoderma granarium* (khapra beetle)	Total—needs to be destroyed
Major postharvest pests	*Cadra cautella* (driedcurrant moth)	Up to 30%
	Tribolium castaneum (red flour beetle)	
Minor postharvest pests	*Corcyra cephalonica* (rice meal moth)	

TABLE E.7. COWPEA: PREHARVEST

	Species (common name)	Losses
Devastating pest	*Locusta migratoria* (migratory locust) *Oedaleus senegalensis* (Senegalese grasshopper)	Up to total
Quarantine pest	*Amsacta moorei* (tiger moth)	
Major pest	*Anoplocnemis curvipes* (giant coreid bug) *Aphis craccivora* (groundnut aphid) *Clavigralla tomentosicollis* (African pod bug) *Maruca vitrata* (lima bean pod borer) *Megalurothrips sjostedti* (bean flower thrips)	
Major pest—role in virus and disease transfer	*Aphis gossypii* (cotton aphid) *Aphis spiraecola* (Spirea aphid) *Ferrisia virgata* (striped mealybug) *Frankliniella schultzei* (cotton thrips) *Nezara viridula* (green stink bug)	
Minor pests	*Agrius convolvuli* (sweet potato moth) *Agrotis ipsilon* (black cutworm) *Aspidiotus destructor* (coconut scale) *Diaphania indica* (cucumber moth) *Helicoverpa armigera* (cotton bollworm) *Lampides boeticus* (pea blue butterfly) *Liriomyza trifolii* (American serpentine leafminer) *Ootheca mutabilis* (leaf beetle, brown) *Ophiomyia phaseoli* (bean fly) *Oxycarenus hyalinipennis* (cotton seed bug) *Spodoptera exigua* (beet armyworm) *Spodoptera littoralis* (cotton leafworm) *Trichoplusia ni* (cabbage looper)	Less than 2%

TABLE E.8. COWPEA: POSTHARVEST

	Species (common name)	Losses
Quarantine pest	*Trogoderma granarium* (khapra beetle)	Total—needs to be destroyed
Major postharvest pests	*Callosobruchus maculatus* (cowpea weevil)	Up to 30%
Minor postharvest pests	*Cadra cautella* (driedcurrant moth) *Corcyra cephalonica* (rice meal moth) *Sitophilus zeamais* (greater grain weevil)	

APPENDIX F
RATIONALE FOR RISK ASSESSMENT METHODOLOGY

The rationale behind the risk prioritization exercise is based upon the nature of risk in agriculture, and it is necessary to define risk to understand its nature. First it is key to recognize that risk is an abstract concept associated with an activity, and cannot exist of itself. Only if an activity is undertaken does the possibility of its outcomes being different to those hoped. Secondly, risk involves a detrimental outcome normally but not always associated with reduced returns on investment. Farmers the world over are aware that there is "a risk" inherent in crop production and that in doing so they "risk" the assets that they invest in the process. Thirdly, the risk inherent in an activity is magnified as the ratio between the potential for downside loss and the capacity to absorb that loss (Weeks 1970) Commercial farmers who risk $1,000 per ha but have the assets to sustain a loss of that size take on less risk than a smallholder for whom the loss of $1,000 might result in complete bankruptcy and loss of livelihood.

Since the word *risk* is widely used colloquially, It is also important to define what, for the purposes of this prioritization exercise at least, risk is not. It is not a specific type of event—such as drought. Although we talk of such events as "risks," they are not risks of themselves. Although the potential for a drought to occur might contribute to the risk inherent in crop production, the fact that a drought might contribute much more to rain-fed crop production that it would to irrigated vegetable production highlights the fact that risk is more a property of an activity than of the event itself. Neither is risk the probability that an event might occur. Although the work *risk* is often colloquially used in place of *chance* or *probability*, the words are not interchangeable. A greater probability that a detrimental event might occur can increase the risk inherent in an activity that is affected by that event, but does not itself constitute that risk.

Risk as described above is an abstract and subjective concept, but it is a critical aspect of the stochastic processes that typify agricultural production systems. Although deterministic value chain analyses can help to determine the optimal path for rural development, the reality is often at odds with deterministic optima, frequently as a result of the impacts of risk upon rural investment decisions. Unless the perceived risks faced by

smallholders are understood, it is difficult to design strategies to meet the objectives of rural development policies.

A key aspect of risk that confounds analyses is that there is no standardized procedure for its quantification and measurement. Although it is possible to measure the ex post impacts of events that contribute to risk in terms of the loss of yield or income resulting from those events, it is more difficult to estimate income foregone by producers who limit their level of investment due to the risks that they perceive to be associated with the production of a specific crop. Although such ex ante impacts of risk might be quantified as potential losses, but their attribution and measurement is extremely complex.

This is even more the case in the livestock sector. The majority of ruminants in Africa are kept under extensive management in ancient systems that were not set up to achieve maximum profit or production but to enable their adherents to be able to live and make use of specific resources in areas where there may not be other viable means of making a living or earning an income. These extensive livestock production systems are strongly driven by tradition, heritage and cultural issues. Normal fiscal indicators may not capture the key characteristics of the system where significant cultural and noncommercial drivers may be as, or even more, important than market drivers.

To understand and prioritize the risks in agricultural and livestock sectors, this assessment has adopted a semi-quantitative approach that does not focus on risk per se. Rather it considers the impacts of the events that contribute to the risk inherent in undertaking a given agricultural enterprise or livelihood. Such impacts are moderated by mitigating measures and their final effect upon a household in terms of perceived risk will depend upon the capacity of each household to absorb the moderated impacts. All three aspects of risk are assessed to generate an eventual listing of key risks and their relative importance to production.

Risks in agriculture can be both idiosyncratic, linked quite specifically to individual commodities (especially prices risks), systemic, where large populations and different crops are affected in the same way (inadequate rainfall being perhaps the most important), or they may be covariate, either through being dependent upon a common causal factor or through one affecting the other (the relation between price and production can often result in covariate risks being faced by different groups of consumers). Each of these aspects of risk must be understood so that the analysis of data and prioritization of risks can be undertaken in an informed and effective manner.

A key aspect of risk prioritization is the perspective from which the priorities should be determined. From a national perspective, the highest priority risks may be those that result in the greatest impact on national and rural economic development, but from the perspective of a smallholder, risk is determined with regard to the livelihood of the household, and especially its food security. It is the fear of food insecurity that drives the majority of investment decisions faced by smallholders so that, when faced with limited resources for investment in crop production, the smallholder will allocate those resources in such a way that the risk to household food security is minimized. It is important therefore to qualify the priorities developed from national data and to note and explain the differences that may occur when these priorities are assessed at the household level.

The methodology thus focuses on three aspects of agricultural risk: (1) the frequency and impacts of specific events upon production at the national and individual household level, (2) the measures employed to mitigate those impacts, and (3) vulnerability, that is, the inverse of the capacity of rural households to absorb the negative impacts of such events. The frequency and impacts of specific events (such as drought, disease epidemics of locust swarms) are assessed from available data and from interviews with key stakeholders. Mitigating measures are assessed primarily through interviews with stakeholders, while the capacity of households to absorb negative impacts has been assessed from both the literature and from discussions with smallholders themselves. Such an approach focuses mainly upon the ex post impacts of events that contribute to risk, while the ex ante impacts of risk itself upon investment decisions are largely ignored. It is recognized that in terms of foregone production the ex ante impacts of risk upon agricultural GDP are potentially as great if not greater than ex post impacts of risk

events (Elbers et al. 2007). Nevertheless, the measurement of perceived risk and its impact upon investment is a complicated task beyond the resources available in this preliminary assessment. Instead this assessment focuses upon available data on the basis that ex ante impacts can be expected to be roughly proportional to ex post losses, so that after taking into account the qualitative input from interviews and focus groups, the priority components of risk can be readily identified and responses recommended.

The first step of the assessment is to determine the timing and extent of reductions in yield below a predetermined threshold, in this case, a third of a standard deviation below the trend line for national yield over time. Losses that exceeded this threshold are judged to have had a significant impact upon national production and the indicative value of such losses is calculated using either domestic or international prices according to the nature of the enterprise. Data for such analyses has been sourced from national statistics or when these have not been readily available through FAOSTAT. For each year that a significant reduction in yield occurred, key stakeholders were canvassed as to the primary causes for the reduction in that year. This information was triangulated from different sources to obtain the most accurate assessment of which events had led to particular crop losses.

National data can provide a useful indication of the main events that resulted in substantial loss of production and reduced agricultural GDP, but such data tends to obscure events of a more localized impact that may nevertheless contribute significantly to the risk inherent in a particular enterprise. These events were captured by extensive canvassing of stakeholders who were asked to identify the key elements of the risk that they faced when growing a crop or undertaking a specific livestock enterprise. Neither does national data cover the extent or effectiveness of mitigation measures that may already exist to reduce the impact of these events (and hence to reduce risk), but these too were captured through stakeholder interviews. Finally, national data cannot reveal the effect of vulnerability to real or potential loss upon producers' investment decisions. For the most part, it was considered that smallholders are homogeneous in their response to risk. This is recognized to be an approximation since the large producers and traders tend to be less risk averse than their smaller counterparts, but it is not anticipated that the approximation would affect the final results of the prioritization.

The qualitative results of interviews and focus groups was combined with the quantitative data to develop an overall assessment of the key risks facing the main subsectors of agriculture (crop production, horticulture and livestock production) to allow for the final prioritization and recommendation of response measures.

The timescale of the risk is important. In the preparation of this assessment, the greatest significance has been ascribed to those elements of risk that have discernible impact within the period of influence of government policy, estimated in this case to be 10 years. Within such a time frame of manageable interest, long-term trends such as climate change contribute little to the ex ante risks perceived by stakeholders, whereas ex post impacts remain below the statistical thresholds used to identify risk events. The changing climate may indeed contribute to agricultural risk, but its impacts are not identified by the empirical methodology used to develop this risk prioritization.

The response model of this methodology is graphically depicted in figure 6.5. It relies upon three different levels of response according to the frequency and severity of impact of risk events. Where risk events may be common, but their direct impacts can be effectively reduced, then mitigation measures are appropriate. Where events are less frequent and those impacts generally exceed capacity for mitigation, then it is more appropriate to undertake the transfer of risk impacts to another party (for example, through insurance). Finally, for the more exceptional risk events that have a substantial impact, coping strategies may be the most effective response. The application of this model is described in more detail in the final section of this report.

APPENDIX G
ANALYSIS OF WEATHER RISK EVENTS

TABLE G.1. FREQUENCY OF LOW RAINFALL EVENTS BY REGION, 1981–2010

	North		North Central				South Central				South East	South West			
Zone / Year	Saint Louis	Louga	Matam	Dakar	Thies	Diourbel	Fatick	Kaolack	Kaffrine	Tambacounda	Kedougou	Kolda	Sedhiou	Ziguinchor	
1980	−0.03	−0.28	−1.40	−0.09	−0.80	−1.02	−1.32	−1.39	−0.39	−1.16	−0.51	−1.94	−1.31	−1.40	Ext Dry
1981	0.98	−0.37	−0.08	−0.39	−0.10	−0.46	−0.33	0.10	0.24	0.63	0.63	−0.17	0.60	0.60	Normal
1982	−0.88	−0.04	−0.86	−0.57	−0.29	−0.86	0.06	−0.51	−0.89	−1.17	−0.97	−0.16	−0.74	−0.79	Normal
1983		−1.81	−0.62	−1.68	−1.57	−1.61	−1.78	−2.13	−1.22	−1.05	−1.57	−1.01	−1.46	−1.53	Ext Dry
1984	−2.09	−0.75	−1.54	−1.11	−0.84	−0.33	−0.21	−0.75	−0.50	−1.34	0.19	−0.14	0.14	−0.23	Dry
1985	−0.63	−0.62	−0.28	0.83	−0.43	−0.91	0.34	−0.67	−0.24	−0.36	0.38	−0.97	−0.80	−0.16	Normal
1986	−0.97	−0.59	−0.34	−0.01	−0.95	−1.15	−0.70	0.30	−0.04	−0.07	0.02	0.64	−0.07	−1.06	Normal
1987	0.25	1.06	0.64	0.38	0.03	−0.68	0.03	0.20	−0.01	−0.75	−0.28	−0.48	0.46	−0.64	Normal
1988	0.65	0.99	0.35	0.49	0.91	0.74	0.28	0.98	0.21	1.09	−0.87	−0.36	0.04	0.26	Normal
1989	0.44	1.84	−0.19	1.47	1.23	1.57	0.72	0.60	−0.18	0.33	−0.62	0.41	0.82	1.05	Excess
1990	−1.19	−0.49	−0.24	−0.95	−0.58	−0.09	−1.53	−1.12	−1.33	−0.58	−1.69	−1.14	−0.43	−0.10	Dry
1991	−0.89	−0.17	−1.28	−0.82	−0.70	−0.97	−0.84	−1.50	−2.04	−1.09	−0.19	−1.46	−1.18	0.94	Dry
1992	−1.16	−1.07	−1.87	−1.45	−0.88	−0.73	−0.78	−0.39	−0.34	−0.72	−1.08	1.14	−0.08	−1.06	Dry
1993	0.11	−0.04	−0.57	−0.46	−0.95	−0.68	−0.17	−0.08	−0.01	−1.23	−0.25	0.33	0.72	−0.15	Normal
1994	−0.41	−0.92	0.73	−0.99	−0.46	0.57	−0.12	0.08	0.44	1.55	0.50	0.89	0.76	−0.39	Normal
1995	0.37	−0.31	−0.51	0.48	0.04	1.20	0.87	−0.62	−0.70	−0.32	−0.58	−0.34	−3.21	−0.07	Normal
1996	−1.44	0.56	−0.10	0.46	−0.09	−1.21	−0.78	−1.24	−0.53	−0.28	−0.19	−1.61	0.21	−0.14	Dry
1997	−0.30	−1.29	−0.33	−1.34	−0.86	−0.47	−1.03	−0.68	−1.11	−0.17	2.01	0.61	−0.19	0.04	Dry
1998	0.16	0.12	−0.85	−0.34	−0.77	−1.02	−0.58	−1.11	−0.50	0.02	0.37	0.96	−0.50	−0.34	Normal
1999	0.64	0.40	1.26	0.69	0.88	1.00	0.62	1.95	1.38	1.31	1.24	1.99	0.76	2.70	Ex Excess
2000	0.19	0.74	2.68	0.54	1.83	0.50	1.27	1.07	0.58	0.26	1.26	−0.21	−0.60	0.25	Excess
2001	1.05	−0.39	0.26	−0.79	0.81	1.10	−0.10	0.26	−0.56	−0.83	0.17	−1.20	−0.18	0.26	Normal
2002	−1.10	−1.54	0.49	−0.71	−1.58	−0.93	−0.99	−0.59	−0.78	−1.50	−0.40	−1.32	−1.47	−1.89	Ext Dry
2003	1.21	−0.65	1.62	0.18	−0.73	−0.73	−0.06	0.57	0.23	2.46	2.89	1.04	1.38	−0.64	Excess
2004	−1.31	0.72	0.80	−1.15	−1.19	−0.59	−0.35	0.06	1.73	0.83	0.93	0.71	0.59	−0.84	Normal
2005	0.67	0.54	0.36	1.93	0.77	1.57	0.59	0.69	1.67	0.54	0.11	1.10	0.98	−0.05	Excess
2006	0.64	−1.16	−1.35	0.21	−0.09	−0.35	0.23	0.38	−0.10	−0.90	−0.39	−0.59	1.09	0.61	Normal
2007	0.03	−0.43	0.60	−0.87	−0.22	0.56	−1.39	−0.50	−0.78	−0.16	−1.78	0.16	−0.19	−1.12	Normal
2008	−0.28	0.66	0.35	0.86	1.09	1.87	1.63	0.58	0.62	1.12	−0.68	0.89	0.77	2.05	Excess
2009	1.03	2.15	0.57	1.19	1.72	1.24	1.96	0.77	0.06	1.21	−0.31	0.76	0.36	0.66	Ex Excess
2010	2.92	2.65	1.65	1.61	2.16	0.95	1.61	2.51	2.93	1.33	1.05	2.00	1.27	1.08	Ex Excess
2011	−0.16	0.49	−0.32	−0.68	0.21	−0.41	−0.38	−0.06	0.02	−0.53	0.98	−0.81	−0.31	−0.23	Normal
2012	1.00	0.16	1.31	1.84	1.13	1.55	2.06	1.42	1.70	1.13	−0.38	0.52	1.83	1.54	Ex Excess
2013	0.51	−0.17	0.04	1.27	1.28	0.79	1.16	0.82	0.43	0.39	0.03	−0.24	−0.05	0.79	Normal

Source: ANACIM 2014.

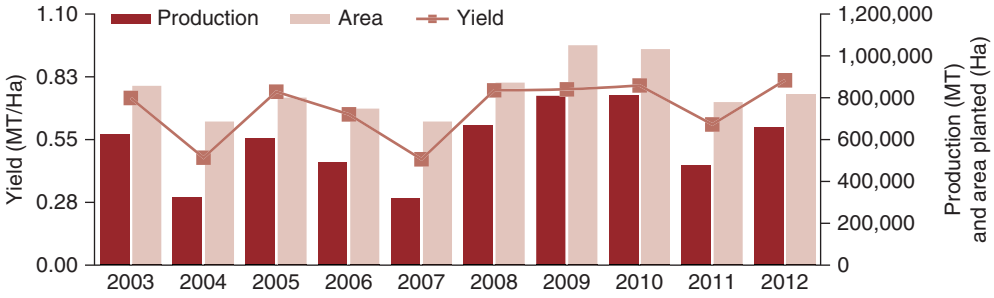
TABLE G.2. FREQUENCY OF HIGH RAINFALL EVENTS BY REGION, 1981–2010

	North		North Central				South Central				South East	South West			
Zone / Year	Saint Louis	Louga	Matam	Dakar	Thies	Diourbel	Fatick	Kaolack	Kaffrine	Tambacounda	Kedougou	Kolda	Sedhiou	Ziguinchor	
1980	–0.03	–0.28	–1.40	–0.09	–0.80	–1.02	–1.32	–1.39	–0.39	–1.16	–0.51	–1.94	–1.31	–1.40	Ext Dry
1981	0.98	–0.37	–0.08	–0.39	–0.10	–0.46	–0.33	0.10	0.24	0.63	0.63	–0.17	0.60	0.60	Normal
1982	–0.88	–0.04	–0.86	–0.57	–0.29	–0.86	0.06	–0.51	–0.89	–1.17	–0.97	–0.16	–0.74	–0.79	Normal
1983		–1.81	–0.62	–1.68	–1.57	–1.61	–1.78	–2.13	–1.22	–1.05	–1.57	–1.01	–1.46	–1.53	Ext Dry
1984	–2.09	–0.75	–1.54	–1.11	–0.84	–0.33	–0.21	–0.75	–0.50	–1.34	0.19	–0.14	0.14	–0.23	Dry
1985	–0.63	–0.62	–0.28	0.83	–0.43	–0.91	0.34	–0.67	–0.24	–0.36	0.38	–0.97	–0.80	–0.16	Normal
1986	–0.97	–0.59	–0.34	–0.01	–0.95	–1.15	–0.70	0.30	–0.04	–0.07	0.02	0.64	–0.07	–1.06	Normal
1987	0.25	**1.06**	0.64	0.38	0.03	–0.68	0.03	0.20	–0.01	–0.75	–0.28	–0.48	0.46	–0.64	Normal
1988	0.65	0.99	0.35	0.49	0.91	0.74	0.28	0.98	0.21	**1.09**	–0.87	–0.36	0.04	0.26	Normal
1989	0.44	**1.84**	–0.19	**1.47**	**1.23**	**1.57**	0.72	0.60	–0.18	0.33	–0.62	0.41	0.82	**1.05**	**Excess**
1990	–1.19	–0.49	–0.24	–0.95	–0.58	–0.09	–1.53	–1.12	–1.33	–0.58	–1.69	–1.14	–0.43	–0.10	Dry
1991	–0.89	–0.17	–1.28	–0.82	–0.70	–0.97	–0.84	–1.50	–2.04	–1.09	–0.19	–1.46	–1.18	0.94	Dry
1992	–1.16	–1.07	–1.87	–1.45	–0.88	–0.73	–0.78	–0.39	–0.34	–0.72	–1.08	**1.14**	–0.08	–1.06	Dry
1993	0.11	–0.04	–0.57	–0.46	–0.95	–0.68	–0.17	–0.08	–0.01	–1.23	–0.25	0.33	0.72	–0.15	Normal
1994	–0.41	–0.92	0.73	–0.99	–0.46	0.57	–0.12	0.08	0.44	**1.55**	0.50	0.89	0.76	–0.39	Normal
1995	0.37	–0.31	–0.51	0.48	0.04	1.20	0.87	–0.62	–0.70	–0.32	–0.58	–0.34	–3.21	–0.07	Normal
1996	–1.44	0.56	–0.10	0.46	–0.09	–1.21	–0.78	–1.24	–0.53	–0.28	–0.19	–1.61	0.21	–0.14	Dry
1997	–0.30	–1.29	–0.33	–1.34	–0.86	–0.47	–1.03	–0.68	–1.11	–0.17	**2.01**	0.61	–0.19	0.04	Dry
1998	0.16	0.12	–0.85	–0.34	–0.77	–1.02	–0.58	–1.11	–0.50	0.02	0.37	0.96	–0.50	–0.34	Normal
1999	0.64	0.40	**1.26**	0.69	0.88	1.00	0.62	1.95	1.38	**1.31**	1.24	1.99	0.76	**2.70**	**Ex Excess**
2000	0.19	0.74	**2.68**	0.54	1.83	0.50	**1.27**	1.07	0.58	0.26	1.26	–0.21	–0.60	0.25	**Excess**
2001	**1.05**	–0.39	0.26	–0.79	0.81	1.10	–0.10	0.26	–0.56	–0.83	0.17	–1.20	–0.18	0.26	Normal
2002	–1.10	–1.54	–0.49	–0.71	–1.58	–0.93	–0.99	–0.59	–0.78	–1.50	–0.40	–1.32	–1.47	–1.89	Ext Dry
2003	**1.21**	–0.65	**1.62**	0.18	–0.73	–0.73	–0.06	0.57	0.23	**2.46**	**2.89**	**1.04**	**1.38**	–0.64	**Excess**
2004	–1.31	0.72	0.80	–1.15	–1.19	–0.59	–0.35	0.06	**1.73**	0.83	0.93	0.71	0.59	–0.84	Normal
2005	0.67	0.54	0.36	**1.93**	0.77	**1.57**	0.59	0.69	**1.67**	0.54	0.11	1.10	0.98	–0.05	**Excess**
2006	0.64	–1.16	–1.35	0.21	–0.09	–0.35	0.23	0.38	–0.10	–0.90	–0.39	–0.59	1.09	0.61	Normal
2007	0.03	–0.43	0.60	–0.87	–0.22	0.56	–1.39	–0.50	–0.78	–0.16	–1.78	0.16	–0.19	–1.12	Normal
2008	–0.28	0.66	0.35	0.86	**1.09**	**1.87**	**1.63**	0.58	0.62	**1.12**	–0.68	0.89	0.77	**2.05**	**Excess**
2009	**1.03**	**2.15**	0.57	**1.19**	**1.72**	**1.24**	**1.96**	0.77	0.06	**1.21**	–0.31	0.76	0.36	0.66	**Ex Excess**
2010	**2.92**	**2.65**	**1.65**	**1.61**	**2.16**	0.95	**1.61**	**2.51**	**2.93**	**1.33**	**1.05**	**2.00**	**1.27**	**1.08**	**Ex Excess**
2011	–0.16	0.49	–0.32	–0.68	0.21	–0.41	–0.38	–0.06	0.02	–0.53	0.98	–0.81	–0.31	–0.23	Normal
2012	**1.00**	0.16	**1.31**	**1.84**	**1.13**	**1.55**	**2.06**	**1.42**	**1.70**	**1.13**	–0.38	0.52	**1.83**	**1.54**	**Ex Excess**
2013	0.51	-0.17	0.04	**1.27**	**1.28**	0.79	1.16	0.82	0.43	0.39	0.03	–0.24	–0.05	0.79	Normal

Source: ANACIM 2014.

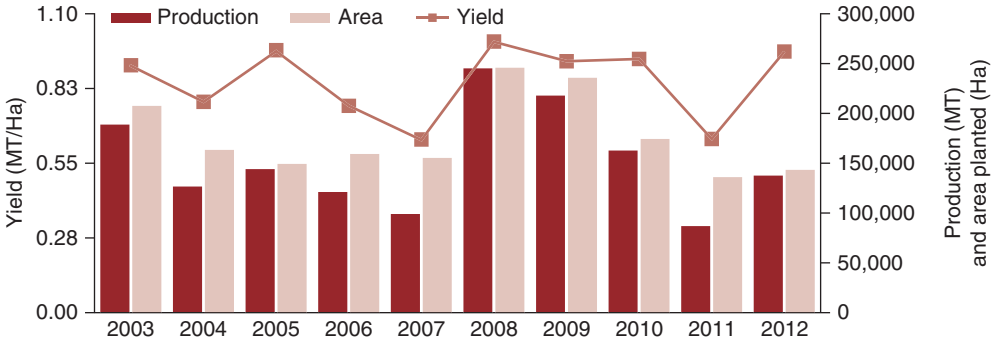
APPENDIX H
CROP PRODUCTION AND YIELDS

FIGURE H.1. MILLET PRODUCTION, 2003–12



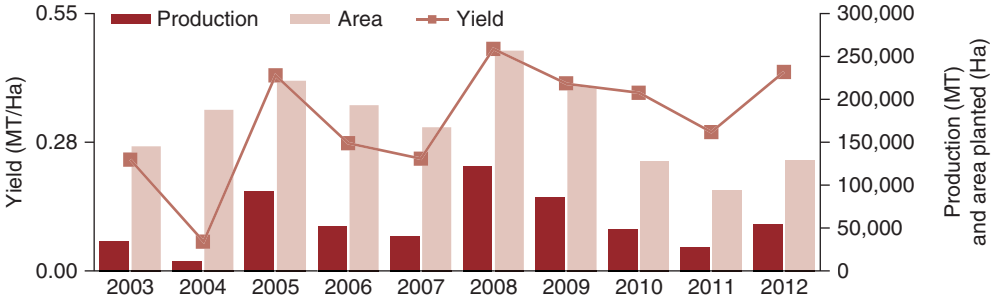
Source: DAPS.

FIGURE H.2. SORGHUM PRODUCTION, 2003–12



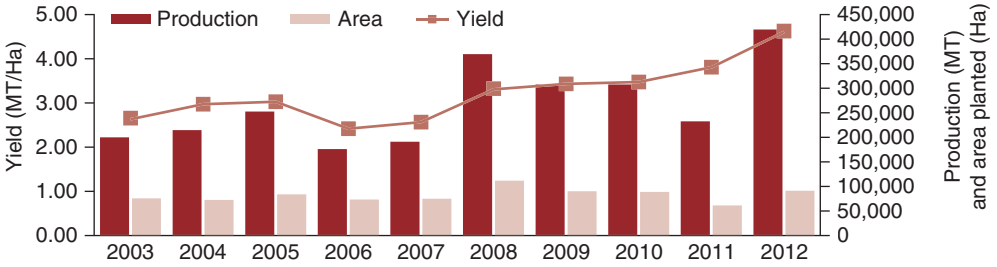
Source: DAPS.

FIGURE H.3. COWPEA PRODUCTION, 2003–12



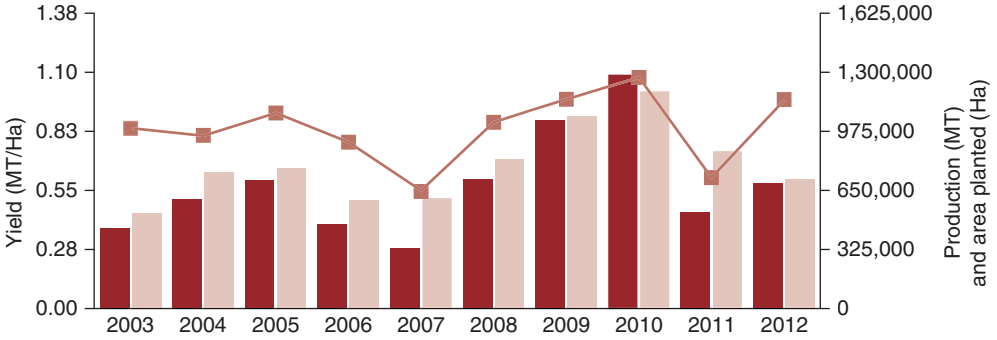
Source: DAPS.

FIGURE H.4. RICE PRODUCTION, 2003–12



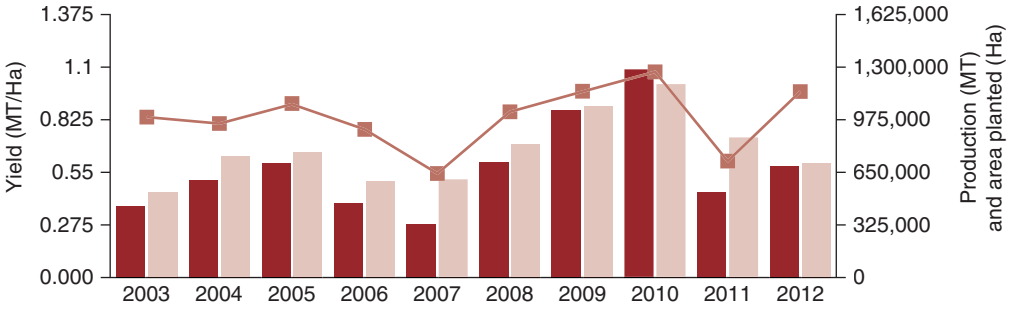
Source: DAPS.

FIGURE H.5. MAIZE PRODUCTION, 2003–12



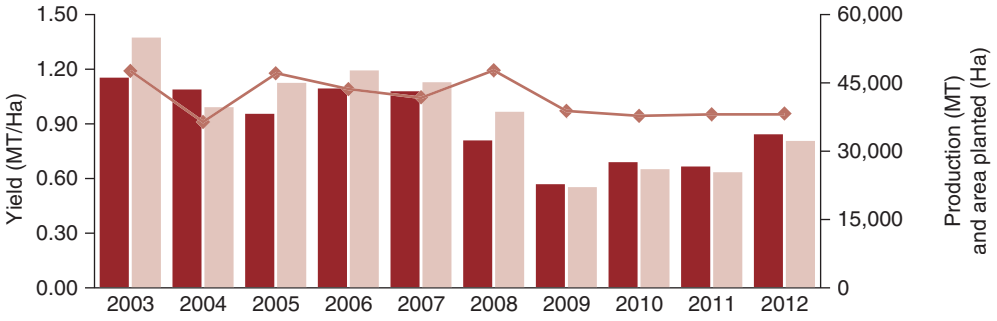
Source: DAPS.

FIGURE H.6. GROUNDNUT PRODUCTION, 2003–12



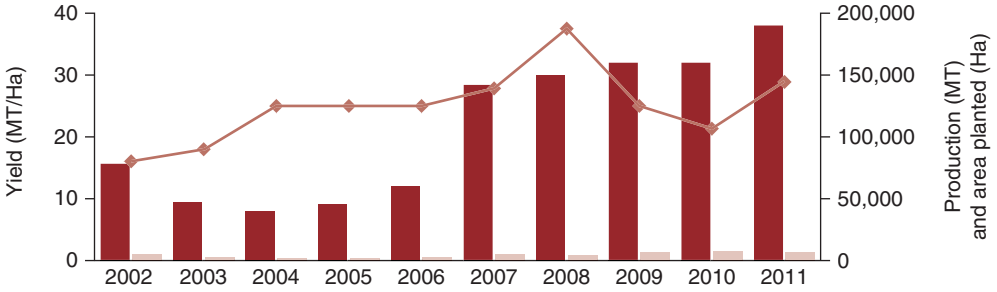
Source: DAPS.

FIGURE H.7. COTTON PRODUCTION, 2003–12



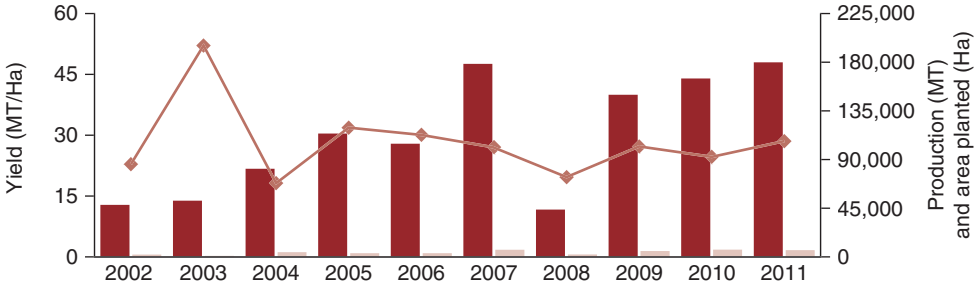
Source: DAPS.

FIGURE H.8. ONION PRODUCTION, 2002–11



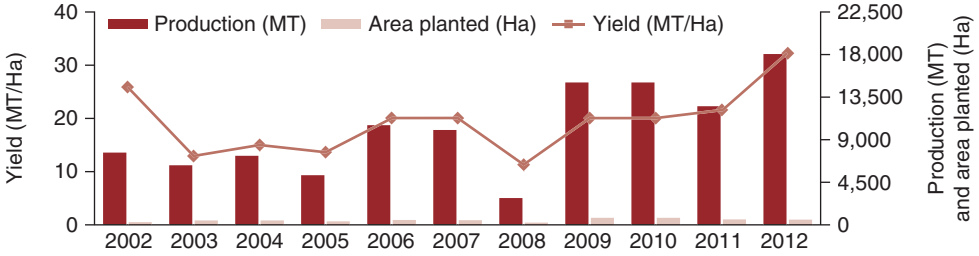
Source: DAPS.

FIGURE H.9. TOMATO PRODUCTION, 2002–11



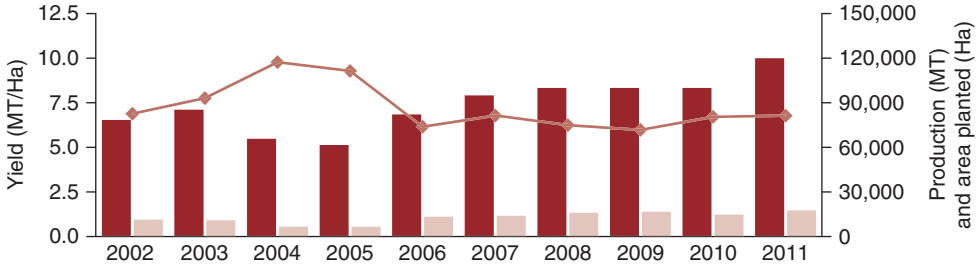
Source: DAPS.

FIGURE H.10. POTATO PRODUCTION, 2003–12



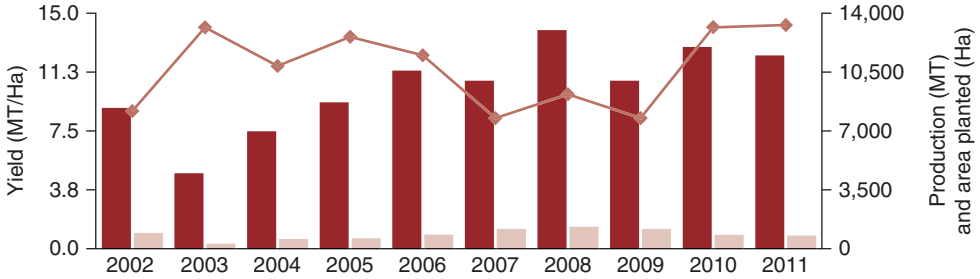
Source: DAPS.

FIGURE H.11. MANGO PRODUCTION, 2002–11



Source: DAPS.

FIGURE H.12. GREEN BEAN PRODUCTION, 2002–11



Source: DAPS.

AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

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